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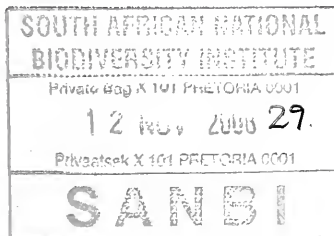
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culoides by Lewis (1962) on the basis of its included filaments and partly included anthers.

Vegetatively, all members of the complex have slender, erect flowering stems bearing few to many, short, \pm wiry, often thread-like lateral branchlets and typically, but not exclusively, just three (rarely two or four to six) foliage leaves. The lower two (rarely one or up to four) leaves have well-developed blades, and the upper one (or two) completely sheath the stem and reach to between the middle of the stem and the base of the spike. The main spike bears relatively few flowers and the lateral spikes have fewer, sometimes only a single flower. Plants referred to *I. rapunculoides* var. *robusta* normally have four leaves but sometimes up to six, with three or four basal and one or two sheathing the stem, and two other varieties rarely have three expanded foliage leaves. None of these vegetative features are, however, unique to the complex, but are shared by several other species of subgenus *Morphixia* (Goldblatt & Manning 1999), notably *Ixia latifolia* D.Delaroche and *I. marginifolia* G.J.Lewis.

Lewis's taxonomic treatment seems to reflect a perception that the morphological variation within the complex was less significant than that encountered between species elsewhere in the genus, presumably because the distinctive flowers of the complex were given undue weight in a genus that is relatively conservative in floral morphology. Some of the variation, especially floral scent, corm features, and the nature of the bracts subtending the branchlets was simply overlooked. The morphological variation in the complex is, nevertheless, extensive and includes: 1, corm tunics that range from coarsely to finely fibrous, or softly papery; 2, cormlets that are either sessile at the base of the main corm or borne on flattened, ribbon-like stolons; 3, flower colour that is often blue to blue-mauve, but also purple, pink or white; 4, leaf shape, which may be narrow, linear, and erect, or sword-shaped and erect, or arching outward and falcate; 5, degree of thickening of the margins of the basal leaves, which is least developed in *I. rapunculoides* var. *flaccida* and most pronounced in var. *robusta* and var. *rapunculoides*; 6, shape and degree of development of the bracts and prophylls subtending the thread-like, lateral branches (here called branchlets when short, or branches when well-developed); 7, length of the perianth tube, mostly 5.5–8.0 mm in var. *rapunculoides*, and 12–16(–18) mm in var. *namaquana*; 8, length of the filaments and anthers, features linked to tube length, and together range from 4.3–6.5 mm in var. *rapunculoides* to a maximum of 9.5 mm in var. *namaquana* and 10.5 mm in var. *subpendula*.

The morphological variation often correlates with ecological and geographical differences but the patterns have until now been inadequately understood. Particularly noteworthy, and from a systematic point of view unsatisfactory, is the local sympatry of some varieties or the parapatric and edaphic or geographic separation of others, in all cases without the occurrence of plants of intermediate morphology.

For example, on dolerite-derived clay soils on the Bokkeveld Plateau and on the Hantamsberg at Calvinia in Northern Cape, both *Ixia rapunculoides* var. *rapun-*

culoides and plants that conform to var. *flaccida* (sensu Lewis 1962), flower contemporaneously within a few metres of one another with no intermediates, indicating complete genetic isolation. Sympatry and synchrony of flowering of two distinct races without the presence of intermediate individuals is usually accepted as an indication of genetic isolation and therefore evidence for their recognition as separate species. Similarly, Lewis (1962) noted that at one of its two localities then known, var. *robusta* grew on rocky dolerite slopes a few metres from typical var. *rapunculoides*, growing on flat, stony loam near a seasonal watercourse. We have confirmed Lewis's observation and amplify it, having seen var. *robusta* growing side by side with var. *rapunculoides*, both taxa maintaining their typical morphology. A comparable situation occurs on the Bokkeveld Plateau near Nieuwoudtville, where typical var. *rapunculoides* grows on tillite-derived clay soils and var. *namaquana* on adjacent sandy soils.

These examples are particularly surprising because the flowers of all these taxa are apparently adapted for pollination by the same insects, a range of medium- and large-bodied bees, mostly Apidae: Anthophorinae, that forage for nectar and acquire loads of pollen while probing the perianth tube (Goldblatt *et al.* 2000 and confirmed here).

Field observations suggest to us that varietal separation within *Ixia rapunculoides* of var. *namaquana*, var. *flaccida* and var. *robusta* is unsatisfactory because the biological situation is not concordant with this taxonomy. The recognition of varieties of a single species is notoriously unevenly applied (Stuessy 1990), but is most often used to denote trivial regional variation, and sometimes only small genetic differences such as flower colour or leaf shape. In our estimation it should never be associated with genetic isolation and effective crossing barriers at the microgeographic level. Raising the rank at which members of the complex are separated to that of subspecies has similar problems. The rank of subspecies is most often used for sets of populations that are isolated geographically and have relatively modest, and often overlapping, morphological differences (Davis & Heywood 1973). As with varietal rank, subspecific rank is inconsistently applied. The examples in *I. rapunculoides* listed above thus accord poorly with treatment at either varietal or subspecific rank.

MATERIALS AND METHODS

We have attempted to resolve this unsatisfactory taxonomic situation outlined above where so-called varieties of a species co-occur and flower synchronously yet maintain their morphological differences by examination of the morphology and ecology of plant populations in the field. These studies were complemented by a study of herbarium collections of the genus at BOL, K, MO, NBG and PRE, the herbaria with the most complete collections of species from the southern African winter rainfall zone. Then, using a morphological species concept, we have compared all significant taxonomic characters of the different sets of populations with their ecology and geography to establish a revised taxonomy of the complex.

RESULTS

Our results, obtained from measuring both living plants in the field and carefully preserved specimens with laid out flowers are presented in tabular form (Table 1). We do not use Lewis's (1962) or De Vos's (1999) measures for any taxa because we apply names in different ways. We have also been careful to include measurements of only well-pressed herbarium specimens because floral parts are particularly susceptible to distortion and can shrink by as much as 20% as they dry, less so when rapidly pressed on glue-covered paper or between the pages of a heavy book.

Members of the *Ixia rapunculoides* complex are not reported in the literature to have scented flowers (Lewis 1962; De Vos 1999; Manning *et al.* 2002). Nevertheless, we have found that plants of most populations have distinctive floral odours. Plants from the eastern part of the range of the complex with nodding white flowers have a particularly intensely sweet, carnation-like odour; typical var. *rapunculoides* has a faint rose scent; var. *namaquana* usually has a violet scent or are occasionally unscented; and var. *robusta* has a faint, unpleasant chemical odour. A population of white-flowered plants allied to var. *rapunculoides* from the Roggeveld Escarpment has a strong fruity odour recalling a combi-

nation of banana and grenadilla, very similar to *Virgilia oroboides* (Fabaceae).

Another feature ignored in the past, is the nature of the bracts and prophylls subtending the branchlets. These range from minute and truncate (var. *rapunculoides*, var. *robusta*) to forked with attenuate tips (Western Karoo plants assigned to var. *flaccida*), to filiform, elongate and recurved (plants from the Klein Roggeveld referred by Lewis (1962) to var. *rapunculoides* or var. *namaquana*).

Corms of members of the complex have until now been described as 'having fairly coarse, often subligneous, reticulate fibres' (Lewis 1962) and neither Lewis nor De Vos (1999) mention the presence of cormlets (cormels) or underground stolons. Texture and composition of the tunics, however, varies considerably and more so than is ever found within a single species of any allied genus of Iridaceae. Hard, coarsely fibrous tunics, matching Lewis's description, are characteristic of var. *rapunculoides*, var. *robusta* and var. *namaquana* and these taxa bear ± sessile cormlets at the base of the main corm. Soft, short-lived tunics of ± membranous layers characterize some plants included in var. *flaccida* and the southern populations of pink-flowered plants referred to var. *namaquana*, and in addition these plants produce

TABLE 1.—Characteristics of members of *Ixia rapunculoides* complex. All varieties recognized by short stamens with filaments and at least bases of anthers included in floral tube (var. *subpendula* is exceptional in this respect as anthers are usually fully exerted). Data are taken from new collections and well-pressed herbarium specimens

Taxon (according to Lewis 1962 in parentheses)	Perianth		Perianth colour	Stamens length mm	Flower		Leaf	
	tube length mm	tepal length mm			orientation	no.	shape	width mm
<i>I. rapunculoides</i> (var. <i>rapunculoides</i> in part)	5.5–8.0(–10.0)	11–16	blue-mauve or pink	fil: 2–3 anth: 2.3–3.5	± horizontal	3–5	falcate	(3–)7–12
<i>I. robusta</i> (var. <i>robusta</i>)	7.5–10.2	(15–)17–20	pink	fil: ± 4 anth: 3.5–4.0	± horizontal	4–6	lanceolate	8–14
<i>I. rivulicola</i> (Sutherland white)	8–9	17–18	white	fil: 3–4 anth: 4.5–5.5	suberect	2 or 3	linear to narrow sword	3–7
<i>I. flaccida</i> (var. <i>flaccida</i> in part)	7–9	± 14	white or flushed pale blue	fil: 2.5–3 anth: ± 2.5	± horizontal		linear to narrow sword	4–9
<i>I. lacerata</i> (var. <i>rapunculoides</i> in part)	10–12(–14)	(10–)12–14	pale blue-mauve	fil: ± 3 anth: ± 3	± horizontal	2–6	falcate to lanceolate	5–10
<i>I. namaquana</i> (var. <i>namaquana</i>)	12–16(–18)	(12–)14–17	cream to pale mauve or pink	fil: 4–5 anth: 3.5–4.5	± horizontal	2 or 3	sword(–falcate)	mostly 8–18
<i>I. oxalidiflora</i> (var. <i>namaquana</i>)	16–22	14–18	pink	fil: ± 4 anth: ± 3.5	mostly ascending	3	linear, erect	6–12(–15)
<i>I. sobolifera</i> subsp. <i>sobolifera</i>	5–6	10–12	slate- or grey-blue	fil: 2–3 anth: 4.0–4.5	± nodding	2 or 3	linear	1.5–3.0
<i>I. sobolifera</i> subsp. <i>carnea</i> (var. <i>flaccida</i> in part)	9–10	12–16	pink	fil: ± 3 anth: 3–4	± nodding	2–4	linear	1.5–3.5
<i>I. sobolifera</i> subsp. <i>albiflora</i> (var. <i>flaccida</i> in part)	6–7	12–17	white	fil: ± 3 anth: ± 3	nodding	2 or 3	linear-sword	4–8
<i>I. contorta</i> (var. <i>rigida</i> excluding the type)	9–13(–14)	9–12	purple	fil: ± 3 anth: 3–4	upright	3	falcate	2–5
<i>I. divaricata</i> (var. <i>subpendula</i> and var. <i>rigida</i>)	8–11	11–14	white, pink or purple	fil: 4–5 anth: 4.0–5.5	upright	4–7	narrow sword	mostly 3–5

fil, filaments; anth, anthers.

quana but represent a novel species, which we describe below as *I. oxalidiflora*.

4. Var. **flaccida**: the type of this variety, from the Olifants River Valley near Clanwilliam in Western Cape, is distinguished by the fairly thin-textured, narrowly lanceolate leaves less than 10 mm wide and \pm half as long as the stem. The white to palest blue flowers are carried \pm horizontally, have a perianth tube 7–9 mm long, while the stamens are inserted \pm 2 mm from the base of the tube, the filaments are 2.5–3.0 mm long and the anthers \pm 2.5 mm long. Plants have three or four leaves, the uppermost one (or sometimes the upper two when four leaves are present) is typically entirely sheathing. The corms have tunics composed of fine or medium-textured, netted fibres and bear cormlets at the base. Plants grow in light sandy soil, among sandstone rocks, on south-trending slopes, in light shade, in thicket communities. They most closely match var. *rapunculoides* in tube and stamen length but apart from differences in leaf shape and texture, they have narrower tepals and corm tunics of finer fibres. Dimensions given by Lewis (1962) and De Vos (1999) for the variety have a wider range because they included additional sets of populations within the taxon.

The first of these populations comprises slender, pink-flowered plants from the Bokkeveld Plateau, the second slate-blue-flowered plants from the Klein Roggeveld, and the third represents white-flowered plants from the central Little Karoo. These variants are recognized by the taller than usual flowering stem, up to 750 mm long when growing under conditions of adequate rainfall, a half or fully nodding flower, and perianth with a pale yellow cup. The leaves of these plants are narrow, linear to narrowly sword-shaped, slightly twisted and often trailing above. Most significantly, the corms differ from all other populations of *I. rapunculoides* sensu Lewis including typical var. *flaccida*, in having soft, soft-papery corm tunics and broad, flat stolons 30–100 mm long terminating in a large cormlet.

At two sites where we have seen the pink-flowered variant, at Glenlyon near Nieuwoudtville and on the Hantamsberg at Calvinia, plants were sympatric with typical var. *rapunculoides*. At a third site, near Grasberg Farm, northwest of Nieuwoudtville, pink-flowered plants were sympatric with var. *namaquana*. The taller pink-flowered plants grew in grass tufts or in bush clumps, whereas var. *rapunculoides* and var. *namaquana* grew on open ground. We conclude that these pink-flowered plants represent an unnamed taxon. Apart from the nodding flower, pink perianth and narrow tepals, flowers of this plant have a tube \pm 9 mm long, filaments \pm 3 mm long, and anthers \pm 4 mm long. The style divides at the anther apices in fully open flowers and the style branches are short, slightly exceeding 1 mm long, thus visible above the anthers. Blue-flowered var. *rapunculoides* growing nearby has a perianth tube 7–8 mm long, filaments \pm 2 mm long, and anthers \pm 3 mm long, whereas var. *namaquana* has a tube (12–)14–16 mm long, anthers \pm 4 mm long and a shorter style.

We have also re-collected and examined the grey-blue- and the white-flowered plants referred by Lewis to var. *flaccida* at sites in the Klein Roggeveld and Little

Karoo. Plants from the latter area grow on south-trending shale slopes in light loamy ground near Oudtshoorn and in the foothills of the Kammanassie Mountains (e.g. Goldblatt & Porter 12291, MO, NBG; Vlok & Schutte 494, MO, NBG), and at a few other sites. These plants resemble most closely the pink-flowered plants from the Bokkeveld Plateau in their tall stature, and narrow, \pm linear leaves and, most significantly in their soft, somewhat papery corm tunics and long, slender stolons bearing a terminal cormlet. The Klein Roggeveld plants, which also have corms with soft tunics and stolons, favour clay or sandy soils in more mesic sites in this semi-arid area, often south-facing slopes. Because these three sets of populations of stoloniferous plants differ in flower colour, branching pattern, and in the strength and quality of their scents, as well as in small differences in size of floral parts, they are probably best regarded as subspecies of a single species, which we call *I. sobolifera*. We propose the names subsp. *albiflora* for the Little Karoo populations, subsp. *carnea* for those from the Bokkeveld Plateau, while the Klein Roggeveld populations constitute subsp. *sobolifera*. The disjunction between the northern subsp. *carnea* and Klein Roggeveld subsp. *sobolifera* may prove to be apparent rather than real as more collecting on the Roggeveld Escarpment is done. Likewise the disjunction between the ranges of subsp. *sobolifera* and the central Little Karoo subsp. *albiflora* will likely be bridged when more exploration at suitable sites between their ranges is undertaken.

5. Var. **subpendula**: plants assigned to this taxon have a discrete ecogeographic range, encompassing the Cold Bokkeveld and surrounding Grootwinterhoek and Hex River Mtns where they grow in seasonally waterlogged sandstone-derived soils. They also comprise a coherent morphological unit, having moderate-sized, white to pale pink flowers with a perianth tube 8–11 mm long, subequal tepals 11–14 \times 6–7 mm, anthers that are 4.0–5.5 mm long and usually fully exerted from the floral tube (sometimes the bases are included), and style branches 1–2 mm long. The narrow leaves are typically 3–5 mm wide (but sometimes up to 10 mm). The remarkable long, straight lateral branches diverge at more than 45° from the main axis and bear flowers in the distal half. These populations seem out of place in the *Ixia rapunculoides* complex, particularly in the large, excluded anthers and relatively longer style branches, and the flowers match most closely those of the related *I. capillaris* which is distinguished not only by the shortly exerted anthers but by the narrow, linear leaves, and particularly by the slender lateral branchlets, which are fairly short, rarely exceeding 10 mm, and usually bearing only one or two, rarely three, flowers. We suspect that var. *subpendula* is not immediately allied to *I. rapunculoides*. While its flowers resemble most closely those of *I. capillaris*, the unusual branching pattern recalls the pink- or red-flowered *I. latifolia*.

Whereas *Ixia capillaris* and *I. latifolia* favour clay soils and are fairly widespread in the southwestern Cape, *I. rapunculoides* var. *subpendula* is restricted to seasonally waterlogged, sandy, stony flats and rocky sites. We recognize var. *subpendula* as a separate species, which we call *I. divaricata* for the unusual, stiff, straight lateral branches that diverge at a sharp angle from the main

axis. Use of the epithet *subpendula* seems inappropriate, for the lateral branches are rarely subpendulous, and usually held above the horizontal.

6. Var. **rigida**: the type of var. *rigida* from the Hex River Valley, does not differ in any significant respect from var. *subpendula* and we therefore include it in that taxon. Other collections from the Cedarberg and Cold Bokkeveld that were assigned to var. *rigida* by Lewis (1962), however, appear to represent a different species. Despite Lewis's comment that the androecium and gynoecium are like those of var. *rapunculoides*, we find the stamens of these plants rather different: the filaments are ± 3 mm long (versus $\pm 2-3$ mm in var. *rapunculoides*), and the anthers are 3–4 mm long, again longer than is usual for var. *rapunculoides*. The flowers also differ from typical var. *rapunculoides* (Table 1) in their upright orientation, and the slightly longer perianth tube, 9–12 mm long (versus 5.5–8(–10) mm in var. *rapunculoides*). We see no particularly close relationship of these plants to typical *I. rapunculoides* or any other member of the complex and treat them as a separate species, *I. contorta*.

Additional variants: there are two more sets of populations allied to *Ixia rapunculoides*. The first of these comprises white-flowered plants from the Roggeveld Escarpment, unknown to Lewis when she revised *Ixia* in 1962. Flowering in October (when all other members of the *I. rapunculoides* complex in the Western Karoo and Roggeveld are in fruit), these plants are confined to the edges of streams that usually have running water until October and remain moist at least until December. Plants are tall, up to 1.2 m high, have membranous corm tunics

that do not accumulate with age, and bear small cormlets at the base of the main corm. The relatively large, nodding flowers have a tube 8–9 mm long, tepals 17–18 \times 5.0–7.5 mm, and anthers 4.5–5.5 mm long, the lower halves included in the perianth tube. The flowers have a strong fruity odour, reminiscent of banana and grenadilla (passion fruit), unique in *Ixia*, but closely matched by the scent produced by *Virgilia oroboides*.

We suggest that the most appropriate treatment for this plant is recognition at species rank and propose the name *Ixia rivulicola*. While its features recall other varieties of the *I. rapunculoides* complex, notably var. *rapunculoides* and var. *flaccida*, it is distinct in flower colour and fragrance, leaf number and shape, in the poorly developed corm tunics, and in the unique riparian habitat.

The second set of populations comprises short plants from the Klein Roggeveld with pale bluish grey flowers. Assigned previously either to var. *rapunculoides* or to var. *namaquana* (Lewis 1962; De Vos 1999) the two lower leaves of the plant have expanded blades and a third sheathing leaf, flowers with a narrowly funnel-shaped perianth tube 10–14 mm long, branchlets subtended by long, recurved, thread-like bracts and prophylls that are bifurcate, and unusual floral bracts with dry, often torn tips, the outer usually with five veins and the inner with three or four. The corms bear basal cormlets and have tunics composed of coarse fibres typical of *Ixia rapunculoides*. We treat these plants as the new species, *I. lacerata*.

Key to *Ixia rapunculoides* and its close allies in subgenus *Morphixia*

Note: care must be taken in measuring floral parts of preserved specimens: depending on the method of drying, the perianth can shrink as much as 20%. Presence of stolons is difficult to establish as they are often left in the ground unless corms are removed with particular care. Filaments are measured from point of insertion on the perianth tube (although they are decurrent) to the base of the anther. The perianth tube is measured from the top of the ovary to the point at which the tepals separate from the upper portion of the tube.

- 1a Foliage leaves linear-filiform, less than 2 mm wide when alive; midvein lying closer to abaxial margin but not evident when alive unless held to the light *I. capillaris* complex
- 1b Foliage leaves linear to lanceolate or falcate but never leathery and filiform, usually more than 2 mm wide in mature plants; midvein evident when alive, central or slightly displaced toward abaxial margin:
 - 2a Filaments reaching at least to top of perianth tube or exerted, thus anthers always completely exerted *I. latifolia* and close allies including *I. divaricata* (= *I. rapunculoides* var. *subpendula*), *I. marginifolia*, and most of the remaining members of subgenus *Morphixia*
 - 2b Filaments included and anthers partly or sometimes also fully included within perianth tube (*I. rapunculoides* complex):
 - 3a Flowers upright; perianth tube 8–13 mm long:
 - 4a Flowers purple with pale yellow cup; main spike and branchlets twisted and flexuose, inclined to nearly horizontal; plants up to 150 mm high *I. contorta*
 - 4b Flowers white, pink or rarely purple with white or pale yellow cup; main spike long, straight and erect, lateral spikes ascending to spreading, with flowers crowded in distal half; plants mostly 300–600 mm high (this taxon does not correctly belong to the complex as filaments are normally exerted 1–2 mm but occasionally reach to just short of mouth of tube) *I. divaricata*
 - 3b Flowers ascending, horizontal or nodding; perianth tube 5–22 mm long:
 - 5a Perianth tube (12–)13–20 mm long; anthers partially or fully included in perianth tube:
 - 6a Anthers half exerted from perianth tube; perianth tube (12–)13–16(–18) mm long; flowers \pm horizontally oriented; corm mostly 12–14 mm diam., with tunics of medium to coarse fibres; cormlets borne at base of main corm *I. namaquana*
 - 6b Anthers fully included in perianth tube; perianth tube 16–22 mm long; flowers mostly ascending; corm mostly 8–10 mm diam., with tunics of fine fibres; cormlets borne at ends of flattened stolons *I. oxalidiflora*
 - 5b Perianth tube 5–12(–14) mm long; anthers partly included in perianth tube:
 - 7a Leaf blades of lower two or three leaves sword-shaped to falcate (rarely sublinear), mostly 8–15 mm wide (rarely 3–7 mm wide), usually less than one third as long as stem (longer if growing through bush); flowers ascending to horizontal; filaments 2–4 mm long; anthers 2.3–4.0 mm long:
 - 8a Bracts and prophylls subtending branchlets bifurcate and attenuate, often directed downward distally; leaves 2(1) with well-developed blades; perianth tube 10–12(–14) mm long; outer bracts with (4)5 major veins, 5-toothed, teeth attenuate *I. lacerata*
 - 8b Bracts and prophylls subtending branchlets short, obtuse to truncate, less than 2 mm long; leaves 2 or 3(4) with well-developed blades; perianth tube 5.5–8.0(–10.2) mm long; outer bracts with 3 major veins, shortly 3-toothed to bluntly 3-lobed:
 - 9a Flowers blue-mauve, occasionally palc pink, with yellow to white throat; expanded foliage leaves 2(3); blades usually falcate;

- base of stem rarely with fibrous collar; perianth tube (5.5–)8.0–10 mm long; anthers 2.3–3.5 mm long *I. rapunculoides*
- 9b Flowers pale pink with white throat; expanded foliage leaves 3(4); blades usually sword-shaped; base of stem covered by collar of fibres; perianth tube 7.5–10.2 mm long; anthers 3.5–4.0 mm *I. robusta*
- 7b Leaf blades linear or narrowly sword-shaped, erect, weakly twisted or trailing distally, mostly 1.5–3.5 mm wide; flowers ascending to horizontal or nodding; filaments 3–4 mm long, inserted at least 4 mm from base of tube; anthers 2.5–5.5 mm long:
- 10a Plants of streambanks and marshes, often growing in water; perianth tube 8–9 mm long; flowers white with yellow throat *I. rivulicola*
- 10b Plants of hillsides and flats; perianth tube 5–10 mm long; flowers white, pale blue, pale pink or slate-blue with white or yellow throat, horizontal or nodding:
- 11a Corm tunics of fine to medium-textured, netted fibres; corms bearing sessile cormlets at base (rarely on slender stolons); perianth whitish or flushed palest blue with white throat; style dividing opposite middle of anthers, style branches extending between them *I. flaccida*
- 11b Corm tunics of soft, ± papery (not fibrous) layers, not accumulating significantly; corms bearing flattened, ribbon-like stolons; perianth pink, bluish grey, slate blue or white; style dividing opposite anther tips, rarely beyond, style branches extending above them *I. sobolifera*

Key to subspecies of *Ixia sobolifera*

- 1a Perianth pink with yellow throat; perianth tube 9–10 mm long; anthers 3–4 mm long, yellow with dark longitudinal lines on anther lobes subsp. *carnea*
- 1b Perianth white with pale yellow throat or slate-blue with white throat; perianth tube 5–7 mm long; anthers 2–3 mm long, uniformly yellow:
- 2a Perianth white with yellow throat; perianth tube 6–7 mm long subsp. *albiflora*
- 2b Perianth slate-blue with white or pale yellow throat; perianth tube 5–6 mm long subsp. *sobolifera*

TAXONOMY

1. *Ixia rapunculoides* Delile in Redouté, Les Liliacées 8: t. 431 (1816). Type: South Africa, without precise locality, collector unknown, illustration in Redouté, Les Liliacées 8: t. 431 (1816). Epitype: South Africa, Northern Cape, Klipkoppies, red clay, 9 August 1961, G.J. Lewis 5853 (NBG, epi., here designated; K, PRE, iso.).

Plants mostly 150–400 mm high. *Corm* subglobose, mostly 14–18 mm diam., with tunics of firm, wiry fibres accumulating in dense mass, bearing small cormlets at base. *Leaves* (2)3(4), lower 2 lanceolate to falcate, mostly (3)–7–12 mm wide, ± one quarter to half as long as stem, margins thickened, plane or lightly crisped, uppermost leaf sheathing stem below spike, rarely unifacial in upper 10–30 mm. *Stem* erect, nodding above, with several to many (up to 10) short, thread-like, ascending to horizontal branchlets subtended by obtuse bracts and prophylls ± 1(–2) mm long. *Main spike* half-nodding, mostly 3–5-flowered, lateral spikes (1)2–5-flowered; bracts translucent sometimes tinged brown especially in fruit, outer with three dark veins, mostly 5–6 mm long, 3-toothed or bluntly 3-lobed, inner about as long, with two dark veins and forked apically. *Flowers* ± horizontally oriented to half nodding, pale blue (mauve or blue-grey) with pale yellow cup, or pink with white cup, faintly rose-scented or evidently unscented; perianth tube 5.5–8.0(–10.0) mm long, widely funnel-shaped, flaring in upper 3–5 mm; tepals subequal, ovate, 11–16 × 4.5–6.0 mm, proximal ± 3 mm forming part of floral cup, spreading at right angles to tube distally. *Stamens* parallel; filaments 2–3 mm long, inserted 2–4 mm above base of tube; anthers 2.3–3.5 mm long, upper half exserted from tube but included in floral cup, pale yellow. *Style* dividing shortly below anther tips, branches 0.7–1.2 mm long, not reaching anther tips. *Flowering time*: August to mid-September, sometimes July. Figure 1A–C.

Distribution: widespread across the Western Karoo, from the Langberg west of Loeriesfontein and the Hantamsberg in the north across the Bokkeveld Plateau

and Roggeveld Escarpment as far south as Sutherland (Figure 2).

Diagnosis and variation: *Ixia rapunculoides*, as circumscribed here, is fairly uniform across its range: it is recognized by the horizontally oriented, mostly blue flowers with a yellow cup (locally pale pink with a white cup), short perianth tube mostly 5.5–8.0 mm long, short filaments 2–3 mm long and anthers 2.3–3.5 mm long and half included in the perianth tube. In the vicinity of the Hantamsberg, the species co-occurs with *I. robusta*, another member of the complex, which was distinguished at the varietal level by Lewis (1962) by the presence of a short collar of fibres sheathing the base of the stem, and three or sometimes four, rather than the usual two leaves with expanded blades. These plants are restricted to dolerite outcrops along the eastern and northern end of the Hantamsberg and wherever we have seen them, typical *I. rapunculoides* grew nearby or among the *I. robusta* plants but was always shorter in stature and with grey-blue flowers, in marked contrast to the tall, pink-flowered *I. robusta*. The occasional presence of three, rather than the usual two expanded leaves, must be regarded as no more than part of the pattern of variation and not as evidence for intergradation with *I. robusta*. Leaf number occasionally varies in typical *I. rapunculoides*, thus some specimens of Lewis 5808 have three broad basal leaves (in two specimens the uppermost of these partly sheaths the stem) very like those of *I. robusta*; and all four specimens of De Vos 2561 have four leaves, the penultimate one partly to almost entirely sheathing the stem. Some plants from the northeastern end of the Hantamsberg (Moordenaarspoort and the Farm Vanrhynshoek) stand out in the species in their unusually narrow leaves (± 3 mm wide), narrow tepals and single flowered branchlets (e.g. Snijman 2068) but at present seem merely to be depauperate rather than representing a separate race or genotype.

In order to fix the application of the name *Ixia rapunculoides*, the type of which is a painting in Redouté's *Les Liliacées* that is not, as far as we know, associated with preserved specimens and possibly of doubtful identity, we have designated an epitype. Plants from the



FIGURE 1.—A–C, *Ixia rapunculoides*, Goldblatt & Porter 12730 (MO, NBG): A, whole plant; B, 1/s flower; C, bracts: outer (left), inner (right). D–F, *Ixia robusta*, Goldblatt & Porter 12738 (MO, NBG): D, whole plant; E, 1/s flower; F, bracts: outer (left), inner (right). Scale bars: 10 mm. Artist: J.C. Manning.

Bokkeveld Escarpment near Nieuwoudtville match the illustration best and of the collections available from there, *Lewis 5853* is representative of the species and distributed in several herbaria.

Flowers of *Ixia rapunculoides* have been shown to be pollinated by large-bodied Anthophorine bees, including *Anthophora diversipes* and *Pachymelus peringueyi* (Goldblatt *et al.* 2000). We have confirmed this initial report at a second population of the species, south of Nieuwoudtville, where only female *Anthophora diversipes* individuals were captured visiting the flowers. The reward for visiting bees is nectar, moderate amounts of which are secreted from septal nectaries and retained in the base of the perianth tube.

Selected specimens

(Collections marked with an asterisk* have a collar of fibres around the stem base; those marked with a + denote gatherings with at least one plant with four leaves.)

NORTHERN CAPE.—3018 (Kamiesberg): summit of Langberg, among dolerite boulders, 3 563' [\pm 1 050 m], (–DB), 5 September 2006, Goldblatt & Porter 12769 (MO, NBG, PRE). 3019 (Loeriesfontein): Farm Taaiboskloof, NW of Loeriesfontein, clay flats, (–CA), 2 September 1982, Snijman 465 (NBG). 3119 (Calvinia): near Nieuwoudtville, (–AC), September 1930, L. Bolus s.n. (BOL19590); Farm Rietfontein, dolerite hill next to road, (–BC), 5 September 2006, *Goldblatt & Porter 12774 (MO, NBG); 51 km on road from Nieuwoudtville to Calvinia, (–BC), 1 September 2006, Goldblatt & Porter 12730 (MO, NBG, PRE); Agter Hantam, near Groot Toring, (–BC), 1 September 2006, *Goldblatt & Porter 12754 (MO, NBG); 5

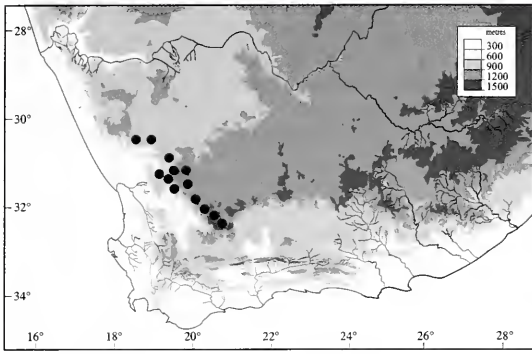


FIGURE 2. —Known distribution of *Ixia rapunculoides*.

miles [8 km] S of Calvinia, (–BD), 21 July 1961, *Lewis 5791* (BOL, K, NBG, PRE); Hantamsberg slopes, (–BD), 4 September 2002, *Goldblatt & Porter 12162* (MO); Farm Vanrhynshoek, east base of Hantamsberg, (–BD), 5 Sept. 2006, *Snijman 2068* (NBG); Farm Wilgebos, S of Calvinia, 10 August 1961, *Lewis 5879* (K, NBG); Kareeboomfontein, SW of Calvinia, (–DA), *Hanekom 2364* (K, MO, PRE); Bloukransberge, Farm Kneu east of escarpment, (–DB), 21 August 1975, *Thompson 2501* (NBG, PRE). 3120 (Williston): near Elandsfontein [between Middelpos and Calvinia], (–AD), 10 October 1928, *+Hutchinson 731* (K); Perdekloof SE of Calvinia to Middelpos, (–DD), *Goldblatt & Porter 12786* (MO, NBG, PRE). 3220 (Sutherland): Farm Kompromis, between Middelpos and Sutherland, (–AB), 5 September 1986, *+De Vos 2561* (NBG); Roggeveld, Bo-Visrivier road opposite Noudrif Farm, (–AB), 8 September 2006, **+Goldblatt & Porter 12800* (MO, NBG); Roggeveld Escarpment, Farm Kruisrivier, 3 km past Ouberg Pass turnoff, stony red-brown clay, 1 270 m, (–AD), August 1986, **+Cloete & Haselau 81* (NBG); Houdenbek, NW of Sutherland, 1 311 m, (–AD), 2 September 1973, **+Oliver 4409* (NBG, PRE); Roggeveld, Sneekrans, Uitkyk, 1 600 m, (–AD), October 1920, *Marloth 9876* (NBG, PRE).

2. *Ixia robusta* (G.J.Lewis) Goldblatt & J.C.Manning, comb. et stat. nov.

I. rapunculoides var. *robusta* G.J.Lewis in Journal of South African Botany 27: 74 (1962). Type: South Africa, [Northern Cape], Moordenaarspoort, 26 miles NE of Calvinia, 26 September 1952, *G.J. Lewis 2503* (BOL!, PRE!, SAM!).

Plants mostly 0.5–1.0 m high. *Corm* subglobose, mostly 14–18 mm diam., tunics of firm, wiry fibres accumulating in dense mass, bearing small cormlets at base. *Leaves* usually 4(5 or 6), lower 3 or 4 lanceolate to sub-falcate, mostly 8–14 mm wide, \pm one quarter to one third as long as stem, margins thickened, usually plane, uppermost 1 or 2 leaves sheathing stem below spike. *Stem* erect, sheathed below ground by collar of fibres, with up to 10 short, slender, ascending branchlets subtended by truncate-apiculate bracts and prophylls 0.5–1.0(–2.0) mm long. *Main spike* suberect, mostly 4–6-flowered, lateral spikes ascending, mostly 2–6-flowered; bracts translucent becoming tinged brown at tips in fruit, outer with three dark veins, (6–)8–10 mm long, 3-toothed or bluntly 3-lobed, subequal or inner slightly longer, with two dark veins and forked apically. *Flowers* \pm horizontally oriented, pale pink with white cup, faintly acrid-metallic-scented or apparently unscented; perianth tube 7.5–10.2 mm long, widely funnel-shaped, flaring in upper 4–5 mm; tepals subequal, narrowly ovate to subspathulate, (15–)17–20 \times 7–9 mm, proximal \pm 3 mm forming part of floral cup, spreading at right angles to tube distally. *Stamens* parallel; filaments \pm 4 mm long, inserted \pm 3.5

mm above base of tube; anthers 3.5–4.0 mm long, half exerted from tube but included in floral cup, yellow. *Style* dividing opposite middle third of anthers, branches 1.5–2.0 mm long, extending between anthers. *Flowering time*: late August to late September. Figure 1D–F.

Distribution: locally in the western Karoo east and north of the Hantamsberg, on flats and lower slopes in heavy, dolerite clay, among dolerite boulders (Figure 3).

Diagnosis and variation: *Ixia robusta* is recognized by its tall stature, pink flowers with a white cup, and at least three (and often four) lanceolate basal leaves that are thick and leathery to almost succulent in texture. The corms, which are difficult to remove from the rocky ground, are large, and covered with wiry tunics, and the underground part of the stem is enclosed by a collar of fibres, a feature often not preserved when the deep-seated corms are removed from the rocky ground.

Wherever we have seen *Ixia robusta*, typical *I. rapunculoides* has been growing nearby and sometimes among plants of *I. robusta*, never with any sign of intergradation. *Ixia robusta* is always taller, has 3 or 4 expanded leaf blades, and branches with more and larger, pink flowers. Associated with the larger flower, the anthers are \pm 4 mm long, the perianth tube is 7.5–10.2 mm long and the style branches are 1.5–2.0 mm long, contrasting with anthers 2.3–3.5 mm long and style branches 0.7–1.0 mm long in *I. rapunculoides*. Lewis's comment that what she called var. *robusta* and var. *rapunculoides* favoured different habitats, the latter in flatter, more sandy situations, is not fully borne out by our observations. We could usually find *I. rapunculoides* growing among *I. robusta* plants, although *I. rapunculoides* also grew in flat, less rocky places where *I. robusta* did not occur. The morphological differences between Lewis's var. *rapunculoides* and var. *robusta*, combined with their sympatry, synchronous flowering and the absence of morphological intermediates, provides convincing evidence that they are separate species.

Although *Ixia rapunculoides* usually has blue-mauve to grey-blue flowers, plants from west of the Hamtamsberg and near Loeriesfontein have a pale pink perianth, identically coloured to *I. robusta* and care must be taken not to confuse *I. robusta* with pink-flowered *I. rapunculoides*: the latter always has short, falcate leaves, usually only two with expanded blades, and lacks a collar of fibres around the stem base. Flower colour alone is not a consistent difference between the two species but where they co-occur, flower colour and scent always differ.

Additional specimens

NORTHERN CAPE.—3119 (Calvinia): Calvinia District, near Elandsfontein, Agter Hantam, 765 m, (–BB), 17 September 1956, *Acocks 19038* (BOL, K, PRE); Agter Hantam, between Moordenaarspoort and Klipwerf, (–BB), 1 September 2006, *Goldblatt & Porter 12746* (MO, NBG); Moordenaarspoort, northeast of the Hantamsberg, among dolerite boulders, (–BD), 1 September 2006, *Goldblatt & Porter 12738* (K, MO, NBG, PRE, S), *12741* (K, MO).

3. *Ixia rivulicola* Goldblatt & J.C.Manning, sp. nov.

Plantae 450–800 mm altae, cormo tunicis submembranosis basi cormo sessile ferenti, foliis (3)4 vel 5, inferioribus 2–4 anguste ensiformibus ad linearibus 3–7 mm

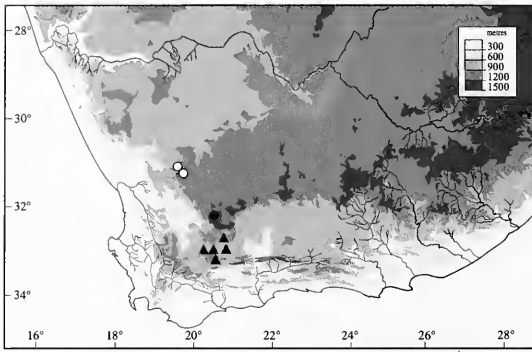


FIGURE 3.—Known distribution of *Ixia robusta*, ○; *I. rivulicola*, ●; and *I. lacerata*, ▲.

latis, spica 2 vel 3-flora, floribus albidis cupula pallide flava intense odoratis, tubo perianthii campanulato 8–9 mm longo, tepalis subaequalibus 17–18 × 5.0–7.5 mm, filamentis 3–4 mm longis, antheris 4.5–5.5 mm longis, stylo tertiam partem superam antherarum adversus dividenti, ramis ± 0.8 mm longis.

TYPE.—Northern Cape, 3220 (Sutherland): Roggeveld Escarpment, drift across Bo-Vis River at Noudrif Farm, in muddy ground, (–AB), 11 October 2004, Goldblatt & Porter 12666 (NBG, holo.; K, MO, PRE, iso.).

Plants 450–800 mm high. *Corm* subglobose, tunics of submembranous fibres soon disintegrating, bearing 1–few sessile cormlets at base. *Leaves* 3(4 or 5), lower 2–4 narrowly sword-shaped to linear, 3–7 mm wide, margins moderately thickened, hyaline when dry, straight, usually ± one third to half as long as stem, uppermost leaf sheathing stem, penultimate leaf often sheathing in lower half. *Stem* with 3–5 straight lateral branchlets mostly held at ± 30° to main axis, filiform, bearing flowers in upper half. *Main spike* mostly 2- or 3-flowered; lateral spikes 1- or 2-flowered; bracts translucent, outer with three dark veins, mostly ± 8 mm long, inner with two dark veins and forked apically. *Flowers* ascending to nearly horizontal, white with pale yellow cup, with strong fruity scent; perianth tube funnel-shaped, 8–9 mm long; tepals subequal, 17–18 × 5.0–7.5 mm, proximal 3–4 mm forming part of floral cup, spreading at right angles to tube distally. *Stamens* parallel; filaments 3–4 mm long, included, inserted ± 3 mm above base of tube; anthers 4.5–5.5 mm long, lower half included in tube. *Style* dividing opposite upper third of anthers, branches ± 0.8 mm long, extending between anthers. *Capsules* and *seeds* unknown. *Flowering time*: mainly October. Figure 4A–C.

Distribution: *Ixia rivulicola* is apparently restricted to the upper reaches of the Bo-Visrivier (Upper Fish River) on the Roggeveld Escarpment (Figure 3). First collected in 1981 by Harry Hall, this plant was not known to Lewis (1962) at the time that she completed her revision of *Ixia*, nor was it dealt with by De Vos (1999). Revisiting Hall's locality in the Roggeveld in October 2004 we found plants growing in shallow water close to the banks of the Visrivier near the entrance to Voëlfontein Farm. Further downstream at the drift across

the river at Noudrif Farm an extensive population was flowering particularly well where the reeds and cattails in the riverbed had been burned the past summer. The plants are tallest when growing in the water among reeds but shorter when the surrounding vegetation is removed. The essentially aquatic habitat of this species is unique in the genus.

Diagnosis and variation: *Ixia rivulicola* is not simply a tall, white-flowered variant of *I. rapunculoides*, for the flowers are larger, with a tube 8–9 mm long, tepals 17–18 mm long, and anthers 4.5–5.5 mm long, compared with the shorter tube, 5.5–8.0(–10.0) mm long in *I. rapunculoides*, tepals 11–16 mm long, and anthers 2.3–3.5 mm long. The ascending to horizontally oriented flowers are white with a pale yellow cup and are particularly sweetly scented, the odour like that of *Virgilia oroboides* (Fabaceae), a combination of grenadilla fruit and violets. Typical blue-flowered *I. rapunculoides* grows on the slopes above the Visrivier and blooms in August and early September, and is in fruit by the time *I. rivulicola* comes into flower at the end of September or in early October. *Ixia rivulicola* responds well to cultivation, and survives outdoors in several degrees of freezing. Plants reproduce liberally by vegetative reproduction, unlike typical *I. rapunculoides*, although both produce cormlets at the base of the main corm.

Like other members of the *Ixia rapunculoides* complex, the flowers of *I. rivulicola* are pollinated by bees. At the type locality they were actively visited by a range of medium-sized and large-bodied bees, including *Apis mellifera*, *Amegilla spilostoma* (both Apidae), *Melitta capensis* (Melittidae), *Megachile* sp. (Megachilidae), *Plesanthidium calvini* and *Patellapis* sp. (both Halictidae). Male and female bees were captured as well as *Apis* workers, and all were found to carry *Ixia*-type pollen on their bodies.

Additional specimens

NORTHERN CAPE.—3220 (Sutherland): Roggeveld Escarpment, Farm Voëlfontein, in vlei in several inches of water, (–AB), 21 October 1981, Hall 5165 (MO, NBG).

4. *Ixia lacerata* Goldblatt & J.C.Manning, sp. nov.

Plantae 150–350 mm altae, cormo tunicis fibrosis, foliis 3, inferioribus 2 linearibus 5–10 mm latis, floribus ± horizontaliter extensis pallide caeruleis in cupula pallide flavis, tubo perianthii 10–12(–14) mm longis anguste campanulato, tepalis subaequalibus ovatis (10–)12–14 × 5–6 mm, filamentis ± 3 mm longis ± 6 mm supra basin tubi insertis, antheris ± 3 mm longis partim supra ex tubo exsertis, stylo medium antherarum adversus dividenti, ramis ± 1 mm longis.

TYPE.—Western Cape, 3320 (Montagu): Klein Roggeveld, about 24 km north of N1 on road to Sutherland, dolerite slope, (–BA), 26 August 2006, Goldblatt & Porter 12702 (NBG, holo.; K, MO, PRE, iso.).

Plants 150–350 mm high. *Corm* subglobose, 14–20 mm diam., with tunics of firm-textured, coarse fibres, bearing small cormlets at base. *Leaves* 3, lower 2 lanceolate to falcate, 5–10 mm wide, plane, sometimes slightly twisted distally, ± one third to one quarter as

long as stem, margins slightly to moderately thickened, uppermost leaf sheathing stem in lower half to two thirds. *Stem* erect, wiry and sometimes somewhat coiled below spike, simple or with 1–3 short lateral branchlets, branchlets thread-like, short and twisted, subtended by filiform, forked or lacerate, distally spreading, silvery bracts and prophylls up to 5 mm long. *Main spike* (2)3–6-flowered, suberect, lateral spikes (1–)3- or 4-flowered; bracts translucent below, becoming rust-coloured in upper third, 6–7 mm long, outer mostly with 5 main veins and 5-toothed at apex, teeth attenuate, sometimes slightly lacerate, inner \pm as long as outer, with 2 main and 2 smaller veins, with 2–4 attenuate teeth. *Flowers* \pm horizontally oriented or suberect, pale blue-mauve, often whitish at base, with pale yellow cup, weakly rose-scented; perianth tube 10–12(–14) mm long; tepals subequal, (10–)12–14 \times 5–6 mm. *Stamens* parallel; filaments \pm 3 mm long, inserted \pm 6 mm from base of tube; anthers \pm 3 mm long, yellow. *Style* dividing opposite middle of anthers, branches \pm 1 mm long. *Capsules* globose, \pm 4 mm long. *Seeds* subglobose, shiny, \pm 1.5 mm at longest axis. *Flowering time*: mainly August to early September. Figure 4D–F.

Distribution: *Ixia lacerata* is restricted to slopes and flats in the Klein Roggeveld, which lies south of the main Roggeveld Escarpment, and the Koedoes Mountains to the west (Figure 3). Plants mostly grow on shales or mudstones of the Ecce System, and only occasionally on rocky, dolerite slopes in heavy clay, the habitat in which typical *I. rapunculoides* most frequently occurs.

Diagnosis and variation: until now the handful of specimens resembling typical *Ixia rapunculoides* from the Klein Roggeveld and Koedoes Mountains have been referred either to this taxon or to *I. namaquana*. Careful examination of flowers and bracts, however, shows that these plants differ consistently in several respects. The perianth tube is 10–14 mm long (vs 5.5–8(–10) mm in var. *rapunculoides* and (12–)13–16(–18) mm in *I. namaquana*); the outer bracts usually have five major veins and the inner, two main and often two smaller veins, with the veins terminating in attenuate teeth; and the margins are dry and often somewhat torn. The bracts in particular are highly diagnostic, contrasting with *I. rapunculoides* and most other species of *Ixia* subgenus *Morphixia*, which have 1- or 3-veined outer bracts and 2-veined inner bracts, the veins terminating in short, acute or blunt teeth. In addition to the floral differences, the flowering stem has only 1–3 branchlets, each bearing 1–3(4) flowers, and the branchlets are subtended by forked, thread-like bracts and prophylls that are spreading or directed downward distally, unlike the short, truncate and inconspicuous bracts in most other members of the *I. rapunculoides* complex, including *I. namaquana* and *I. rapunculoides* itself.

Ixia lacerata is poorly represented in herbaria and appears to have first been collected by the traveller-explorer William Burchell, who found the species on the Windheuwel in the Koedoes Mountains in July, 1811. Surprisingly, Burchell's collection attracted no botanical attention, although at the time the only *Ixia* known with short stamens and included filaments was *I. rapunculoides*, described in 1816 and not then known from any wild locality.

Our observations on the pollination of *Ixia lacerata* made in September 2006 at two sites showed that the most common insect visitor was an unnamed long-proboscid fly, *Prosoeca* sp. (Nemestrinidae). This fly, also the main pollinator of the long-tubed *Romulea syringodeoflora* M.P.de Vos (Goldblatt & Manning 2007), has a proboscis 10.5–11.5 mm long, a close fit for the perianth tube of *I. lacerata*, the base of which contains concentrated nectar, of 38–49% sucrose equivalents. Because of the short stamens in the species, contact between the anthers and the fly's body would be limited to the base of the proboscis. A less frequent visitor was the bee *Anthophora diversipes* (Apidae: Anthophorinae). Anthophorine bees are common visitors to flowers of members of the *I. rapunculoides* complex (Goldblatt *et al.* 2000) and are assumed to be their most important pollinators. The significance of the visits by *Prosoeca* species remains to be determined.

Selected specimens

NORTHERN CAPE.—3220 (Sutherland): Houthoek, Sutherland, (–CA), 13 August 1968, *Hanekom 1069* (K, PRE); Roggeveld Escarpment, Farm Kraairivier, 5 km from Ceres turnoff on Sutherland–Matjiesfontein road, yellow clay-gravel, (–CB), 25 August 1986, *Cloete & Haselau 8* (NBG); Windheuwel, Koedoes Mountains, (–CC–CD), 22 July 1811, *Burchell 1285* (K); 82 km S of Sutherland, rocky ridge, (–DC), 31 August 1993, *Goldblatt & Manning 9658* (NBG, MO); valley \pm 9.5 km below Komsberg Pass, Klein Roggeveld, (–DB), 8 September 2006, *Goldblatt & Porter 12802* (MO, NBG, PRE); Klein Roggeveld, Farm De Hoop S of Komsberg Pass, (–DC), 30 September 2004 (fruiting), *Goldblatt & Porter 12659* (MO, NBG).

WESTERN CAPE.—3220 (Sutherland): 19 miles [\pm 30 km] N of Matjiesfontein, (–DC), 15 September 1955, *Acoks 18440* (K, PRE); 1 km along turnoff to Komsberg Pass, (–DC), 26 August 2006, *Goldblatt & Porter 12708* (MO, NBG); north of Matjiesfontein on road to Sutherland, Farm Nuwerus, (–DC), 14 September 2004, *Snijman 1929* (NBG).

5. *Ixia sobolifera* Goldblatt & J.C.Manning, sp. nov.

Plantae (150–)250–750 mm altae, cormo stolonifero tunicis \pm papyraceis, foliis 3, inferioribus 2 laminis linearibus vel anguste ensiformibus (1.5–)2.0–5.0(–8.0) mm latis, floribus nutantibus carneis vel ardesiaco-caeruleis cupula alba vel pallide flava usitate fragrantibus, tubo perianthii 5–10 mm longo infundibulari, tepalis subaequalibus ovatis 10–17 \times 4.5–7.5 mm, filamentis 2–3 mm longis 3–4 mm supra basem tubi insertis, antheris 3.0–4.5 mm longis partis supra ex tubo exsertis, stylo apicem antherarum adversus dividendi, ramis styli 1.0–1.5 mm longis.

TYPE.—Northern Cape, 3320 (Montagu): north of Matjiesfontein on road to Sutherland, (–BA), 9 September 2006, *Goldblatt & Porter 12809* (NBG, holo.; MO, PRE, iso.).

Plants (150–)250–750 mm high. *Corm* subglobose, 8–12 mm diam., with soft, \pm papery tunics, producing flattened, corm-bearing stolons from base. *Leaves* 3, lower 2 linear, often trailing above, (1.5–)2.0–5.0(–8.0) mm wide, \pm half as long as stem, margins plane, barely thickened, edges flat or concave, uppermost leaf sheathing stem below spike. *Stem* erect, with 1–5 twisted, filiform branchlets subtended by forked, attenuate bracts and prophylls 2–5 mm long. *Main spike* nodding, 2–5(–7)-flowered, lateral spikes nodding, (1)2–4(5)-flowered;



FIGURE 4.—A–C, *Ixia rivulicola*, Goldblatt & Porter 12665 (MO, NBG): A, whole plant; B, l/s flower; C, bracts: outer (left), inner (right). D–F, *Ixia lacerata*, Goldblatt & Porter 12702 (MO, NBG): D, whole plant; E, l/s flower; F, bracts: outer (left), inner (right). G–I, *Ixia sobolifera* subsp. *carnea*, Goldblatt & Porter 11810 (MO, NBG): G, whole plant; H, l/s flower; I, bracts: outer (left), inner (right). Scale bars: 10 mm. Artist: J.C. Manning.

bracts translucent, or becoming dry and brown distally with age, outer with three dark veins, 6–10 mm long, inner similar but with two dark veins and forked apically. *Flowers* half to fully nodding, pink or slate blue with white cup, or white with pale yellow cup, faintly rose- to strongly carnation-scented; perianth tube 5–10 mm long, funnel-shaped, flaring in upper ± 5 mm; tepals subequal, ovate or narrowly ovate, 10–17 \times 4.5–7.0 mm, proximal ± 3 mm forming part of floral cup, spreading at right angles to tube distally. *Stamens* parallel; filaments 2–3 mm long, inserted 3–4 mm above base of tube; anthers 3.0–4.5 mm long, included or half exserted from tube but included in floral cup, uniformly pale yellow or

marked with dark, longitudinal streaks. *Style* dividing opposite or slightly beyond anther tips, branches 1.0–1.5 mm long, usually exceeding anthers when mature. *Flowering time*: August to mid-September.

Distribution: *Ixia sobolifera* extends from the Langberg and Kubiskou ranges northwest of Loeriesfontein in Northern Cape though the western Karoo and interior Western Cape to the Little Karoo (Figure 5). More detailed distribution and habitat information is provided under the subspecies.

Diagnosis and variation: included by Lewis (1962) in *Ixia rapunculoides* var. *flaccida*, *I. sobolifera* is rec-

on shale slopes but northwest of Nieuwoudtville, near the Farm Biekoes, plants grow on sandy tillite soils among sandstone rocks. The species is fairly common in the rocky dolerite hills of the Nieuwoudtville Wildflower Reserve and in similar habitats to the south on the farms Glenlyon and Oorlogskloof.

Diagnosis and variation: apart from the distinctive pink perianth, for which the taxon is named, an odd feature of subsp. *carnea* is the presence of dark longitudinal lines on the anthers that contrast with the otherwise yellow colour. Plants are sympatric and bloom at the same time as the longer-tubed *I. namaquana* northwest of Nieuwoudtville and with *I. rapunculoides* in the dolerite hills east of Nieuwoudtville and on the Hantamsberg.

Additional specimens

NORTHERN CAPE.—3018 (Kamiesberg): Langberg W of Loeriesfontein, wet gully, on shale, (–DB), 5 September 2006, *Goldblatt & Porter* 12764 (MO, NBG, PRE). 3019 (Loeriesfontein): upper slopes and summit of Kubiskou, in shale or dolerite, (–CD), 14 September 2006, *Goldblatt & Porter* 12820 (MO, NBG, PRE). 3119 (Calvinia): Klipkoppies, among rocks, (–AC), 9 September 1961, *Lewis* 5862 (NBG); 4 miles [6.4 km] N of Nieuwoudtville, (–AC), September 1930, *L. Bolus* s.n. (BOL19589); between Grasberg and Nieuwoudtville, (–AC), 8 August 1961, *Lewis* 5840 (NBG), [co-blooming with *I. namaquana*], 11 September 2004, *Goldblatt & Porter* 12406 (MO, NBG); dolerite koppies, Nieuwoudtville Wildflower Reserve, (–AC), 12 September 2004, *Goldblatt & Porter* 12422 (MO, NBG); Hantamsberg, lower S-facing slopes, (–BC), 4 September 1991, *Goldblatt* 9169 (MO, NBG); Hantamsberg slopes, after fire, in tufts of grass and among shrubs [sympatric and blooming with *I. rapunculoides*], (–BD), 4 September 2002, *Goldblatt & Porter* 12161 (MO, NBG).

5c. subsp. *albiflora* *Goldblatt & J.C.Manning*, subsp. nov.

Plantae 400–650 mm altae, laminis foliorum anguste ensiformibus vel linearibus 4–8 mm latis, caule 2 vel 3(–5) ramoso, spica 4– vel 5(–7) flora, bracteis usitate 6–8 mm longis, foliis albis cupula pallide flava intense fragrantibus, tubo perianthii 6–7 mm longo, tepalis 12–17 × 5.0–7.5 mm, antheris ± 3 mm longis flavis.

TYPE.—Western Cape, 3322 (Oudtshoorn): Farm Buffelskloof, 35 km from Dysseldorp on Laudina road, south-facing shale hillside, (–DA), 12 September 2003, *Goldblatt & Porter* 12291 (NBG, holo.; K, MO, PRE, iso.).

Plants 400–650 mm high. *Leaves* linear to narrowly sword-shaped, 4–8 mm wide. *Stem* erect, with 2 or 3(–5) suberect to spreading, filiform branchlets subtended by silvery-translucent bracts mostly 3–4 mm long. *Main spike* 4- or 5(–7)-flowered, lateral spikes (1)2- or 3(–5)-flowered; bracts membranous and translucent, mostly 6–8 mm long. *Flowers* creamy white with pale yellow cup, sometimes flushed grey-mauve outside, nodding, intensely carnation-scented; perianth tube 6–7 mm long, tepals 12–17 × 5.0–7.5 mm. *Filaments* ± 3 mm long; anthers ± 3 mm, uniformly pale yellow; style reaching anther tips. *Flowering time:* August to mid-September.

Distribution: mainly restricted to the central Little Karoo, subsp. *albiflora* is known from just a handful of sites, mostly south and east of Oudtshoorn, with one record from the northern foothills of the Swartberg, east of Prince Albert (Figure 5). We also provisionally

include here a collection from Montagu (*Page* s.n.), which is isolated some 150 km west of the remaining stations. The plants have white flowers, typical of *albiflora*, with a perianth tube ± 7.5 mm long and anthers ± 4 mm long, but the corm has finely fibrous tunics resembling those of *I. flaccida* and shows no evidence of stolons, critical in recognizing *I. sobolifera*. The bracts are ± 7 mm long, also consistent with *I. sobolifera* rather than *I. flaccida* which has slightly shorter bracts, typically ± 6 mm long. The locality of the *Page* collection, the Little Karoo, accords better with subsp. *albiflora* than *I. flaccida*, which occurs to the west in the Olifants River Valley. Subsp. *albiflora* favours moist, south-facing slopes and grows in pockets of loamy soil on shale in renosterveld. The habitat for the collection from Montagu is from rocky slopes and cliffs, but the rock type is not recorded.

Diagnosis and variation: subsp. *albiflora* is distinguished from its sister subspecies mainly by the white, strongly carnation-scented flowers with a yellow cup, and also by the 4- or 5(–7)-flowered main spike, perianth tube 6–7 mm long (perianth tube 9–10 mm long in subsp. *carnea* and 5–6 mm in subsp. *sobolifera*), and often broader leaves, 4–8 mm wide.

Lewis (1962) included the two collections of *Ixia sobolifera* subsp. *albiflora* known to her (*Page* s.n. and *Thorne* s.n.) in *I. rapunculoides* var. *flaccida* (now *I. flaccida*), which occurs in the Olifants River Valley, well to the west. As we have discussed above, this is distinct from the stoloniferous *I. sobolifera*, which also has larger flowers with a longer perianth tube and longer anthers.

Additional specimens

WESTERN CAPE.—3320 (Montagu): Montagu Baths, common on rocky slopes and cliffs in gorge, (–CC), August 1920, *Page* s.n. (BOL). 3321 (Ladismith): SW of Oudtshoorn near Perdebont, (–DB), 12 August 2004, *Vlok & Schutte* 494 (MO, NBG). 3322 (Oudtshoorn): lower north slopes of the Swartberg, Farm Frisgewaagd, burned S-facing slope, 900 m, in loamy soil, (–AD), 12 September 1986, *Vlok* 1586 (MO, NBG, PRE); Oudtshoorn, Grootkop, 440 m, deep loamy soil on S-facing slope, rare, (–CA), 18 August 2005, *Vlok & Schutte* 506 (NBG); Oudtshoorn, Kleinfontein, (–CA), August 1931, *Thorne* s.n. (SAM51702); Farm Buffelskloof, 35 km from Dysseldorp on Laudina road, south-facing shale hillside, (–DA), 12 September 2004, *Goldblatt & Porter* 12484A (MO, NBG).

6. *Ixia namaquana* *L.Bolus*, South African Gardening and Country Life 21: 368 (1931). *I. rapunculoides* var. *namaquana* (*L.Bolus*) *G.J.Lewis*: 76 (1962). Type: South Africa, [Northern Cape], Klipfontein, September 1883, *H. Bolus* as Herbario Normale Austro-Africana 698 (BOL!, lecto., designated by *De Vos* (1999: 15); B, G, K!, PRE!, SAM!, Z, isolecto.).

Plants mostly 300–500 mm high. *Corm* 12–15 mm diam., with tunics of medium-textured to coarse fibres. *Leaves* 3, lower 2 sword-shaped to falcate, mostly 8–18 mm wide (particularly broad in the type), margins thickened and hyaline, sometimes minutely crisped, usually ± one third as long as stem but sometimes much shorter, uppermost leaf sheathing stem. *Stem* with several short, filiform, twisted lateral branchlets, subtended by short bracts ± 2 mm long. *Main spike* erect, 2- or 3-flowered, lateral spikes 1- or 2-flowered; bracts translucent, outer with 3 dark veins, ± 10 mm long, with 3 short, sub-

equal teeth, inner with 2 dark veins and forked at apex. *Flowers* held \pm horizontally, whitish to pale mauve, lilac, pale blue or pink with yellow cup, rim of cup marked with a band of short vertical lines, often flushed lilac to mauve outside, violet-scented or unscented; perianth tube 12–16(–18) mm long, narrowly funnel-shaped; tepals subequal, ovate, (12–)14–17 \times 5–7 mm (inner), 6–8 mm (outer), proximal 4–6 mm forming part of floral cup, spreading at right angles to tube in distal 10–12 mm. *Stamens* parallel; filaments erect, 4–5 mm long, inserted \pm 6–10 mm above base of tube; anthers 3.5–4.5 mm long, upper half exerted from tube but included in floral cup. *Style* mostly dividing opposite upper third of anthers, branches \pm 1 mm long, extending between anthers (in the type, dividing at anther tips with branches arching above anthers and 1.5 mm long). *Capsules* ovoid, \pm 9 mm long. *Seeds* unknown. *Flowering time*: mainly August to mid-September, rarely October. Figure 6A–D.

Distribution: *Ixia namaquana* has a scattered distribution in Northern and Western Cape, and has been recorded from the Richtersveld and the high ground around Steinkopf in northern Namaqualand, from the southern Kamiesberg in central Namaqualand, and from the Bokkeveld Mtns and northern Cedarberg to the south (Figure 7). The disjunct distribution between the Steinkopf area of Namaqualand and the southern Kamiesberg is a pattern shared by *Brunsvigia pulchra* (Amaryllidaceae) and is probably related to the somewhat lower altitude and associated reduction in precipitation of the country between these two high-lying points. Another species pair with this distribution is *Hessea pilosula* (Amaryllidaceae) from the Steinkopf area and its sister species *H. incana* from the Kamiesberg. There are no significant differences between the northern Namaqualand populations of *I. namaquana* and those from the south except for the bright pink flower colour (rather than pale mauve to blue) in the type form, which occurs on clay soils. In the Kamiesberg, *I. namaquana* occurs on granitic gravel but in the Bokkeveld Mtns, Gifberg and Cedarberg it grows in sands derived from Cape Sandstone formations. Plants that we assign to *I. namaquana* from the Wiedouw River (Lewis 1980), south of Vanrhynsdorp, probably grow on loam among limestone outcrops, the main formation there but we have not seen the species at this site ourselves.

Diagnosis and variation: *Ixia namaquana* is readily distinguished from other members of the *I. rapunculoides* complex by the longer perianth tube, mostly 13–16 mm, short branchlets bearing 1 or 2 flowers each, and corm with tunics of coarse, netted fibres. The flowers are relatively large with tepals mostly 14–16 mm long and anthers 3.5–4.5 mm long. The proximal part of the tepals is directed forward, forming part of the floral cup, which fully encloses the stamens. The flowers are usually sweetly scented but are apparently unscented in plants from Vanrhyn's Pass and Nieuwoudtville in the Bokkeveld Mtns. Pink-flowered plants with a perianth tube 16–22 mm long from the Hex River Pass and nearby that were identified as *I. namaquana* by De Vos (1999) and others, are here referred to the new *I. oxalidiflora*. This species can be distinguished from *I. namaquana* by the longer perianth tube, suberect rather than

horizontally spreading flowers, fully included anthers, and perhaps most significant, by the corms with papery to finely fibrous tunics and bearing ribbon-like stolons.

Plants from a seasonally wet site near Leliefontein in the Kamiesberg, referred to *Ixia namaquana* by De Vos in various herbaria, differ in their later flowering time, October and November, and in having a white perianth with tepals pale blue at the tips, filaments shortly exerted, a perianth tube \pm 7 mm long, and narrow leaves. They are obviously misplaced in *Ixia namaquana* and apparently represent a late-flowering ecotype of *I. latifolia* var. *ramulosa* from moist habitats.

First collected by Harry Bolus in 1883 at Klipfontein near Steinkopf in northern Namaqualand, *Ixia namaquana* was described by his niece, H.M.L. Bolus in 1931. The species was based on the Bolus collection and one more (*Herre s.n.*) from nearby, both having the large, pink flowers that characterize the northern populations of the species. The presence of pale lilac- to almost white-flowered plants otherwise resembling *I. namaquana* from the Bokkeveld Mountains, well to the south, was only established later and Lewis (1962) included these as well as the northern Namaqualand plants in *I. rapunculoides* var. *namaquana*. In De Vos's (1999) account of var. *namaquana*, its range is extended to include the northern Cedarberg (Compton 24239), and the Laingsburg and Worcester Districts, but no species are cited from the latter two areas, and we do not recognize the taxon from south of the Cedarberg. The presence of *I. namaquana* in the Kamiesberg of central Namaqualand was first recognized by De Vos (1999); some plants from there were referred by Lewis to the shorter-tubed var. *rapunculoides*. The Kamiesberg plants more closely resemble those from the Bokkeveld Mountains rather than those from northern Namaqualand. The type of *I. namaquana* has particularly large flowers, with the tube up to 18 mm long, and the style divides opposite the anther tips with the branches extending above them. Specimens of other northern Namaqualand collections are less well pressed and it is impossible to say if the features of the type plants are shared with all other specimens from the area. The northern populations need more careful study.

Selected specimens

NORTHERN CAPE.—2917 (Springbok): Richtersveld, Kalkfontein, (–AA), without date, *Meyer s.n.* (NBG178595); Klipfontein, (–BA), without date, *Marloth 12678* (PRE), 29 August 1935, *Compton 5411* (BOL, K, NBG); Kasteelpoort, Steinkopf, (–BA), 7 September 1929 (NBG); Steinkopf, western mountains, (–BA), 9 September 1929, *Herre s.n.* (STEU11846 in BOL, K, PRE); Steinkopf, (–BA), 24 August 1959, *Lewis 5494* (NBG); 4 km W of Steinkopf, (–BA), September 1993, *Williamson 5301* (NBG). 3018 (Kamiesberg): Leliefontein, (–AC), 2 October 1947, *Rodin 1474* (PRE); Kamiesberg, Reliefontein, slopes south of Nartjesdam, (–CA), 1 September 1975, *Oliver 5972* (NBG, PRE). 3119 (Calvinia): between top of Vanrhyn's Pass and Nieuwoudtville, (–CA), 23 August 1950, *Lewis 2287* (SOM); Nieuwoudtville, Glenridge, (–AC), 18 August 1960, *Lewis 5725* (BOL, K, NBG); Grasberg, NW of Nieuwoudtville, (–AC), 16 September 1961, *Barker 9553* (BOL, MO, NBG, PRE); Grasberg road, NW of Nieuwoudtville, Farm Biekoes, (–AC), 11 September 2004, *Goldblatt & Porter 12407A* (MO); Lokenburg, (–CA), 29 August 1941, *Esterhuysen 5755* (BOL, PRE); Oorlogskloof Nature Reserve (grid A6), 680 m, sandy loam, (–CA), 4 August 1988, *Pretorius 75* (MO, NBG, PRE); top of Botterkloof Pass, (–CC), 21 July 1961, *Lewis 5789* (BOL, K, NBG, PRE).

WESTERN CAPE.—3119 (Calvinia): Koebe Valley, (–CA), 1 September 2001, *Goldblatt & Porter 11805* (MO, NBG). 3118



7. *Ixia flaccida* (G.J.Lewis) Goldblatt & J.C.Manning, comb. et stat. nov.

I. rapunculoides var. *flaccida* G.J.Lewis in Journal of South African Botany 27: 74 (1962). Type: South Africa, [Western Cape], Boschklouf, 7 Aug 1896, R. Schlechter 8432 (BM, BOL!, G, K!, L, MO!, PRE (two sheets)!, S, Z, syn.).

Plants 200–350 mm high. *Corm* subglobose, tunics of medium-textured, netted fibres, bearing 1–few sessile, basal cormlets and rarely a short stolon. *Leaves* 3(4), lower 2(3) sword-shaped to linear, 4–9 mm wide, margins hardly thickened, straight, usually about half as long as stem, uppermost leaf sheathing stem. *Stem* erect, slender-filiform, with 4–6 loosely twisted, filiform branchlets up to 35 mm long, spreading at right angles to main axis, subtended by minute, acute bracts and prophylls \pm 1 mm long. *Main spike* 2–4-flowered, lateral spikes 1–3-flowered; bracts translucent light brown, outer with three dark veins, mostly 5–6 mm long, inner as long or slightly longer than outer, with two dark veins and forked at apex. *Flowers* horizontally oriented, white or pale blue with white to greenish cup, apparently unscented; perianth tube funnel-shaped, 7–9 mm long; tepals subequal, \pm 14.0 \times 3.5–4.5 mm, proximal 3–4 mm forming part of floral cup, spreading at right angles to cup distally. *Stamens* parallel; filaments 2.5–3.0 mm long, included in tube, inserted 3–4 mm above base of tube; anthers \pm 2.5 mm long, lower half included in tube. *Style* dividing at mid-anther level, branches \pm 1 mm long, extending between anthers. *Capsules* and *seeds* unknown. *Flowering time*: late July to early September.

Distribution: restricted to the Olifants River Valley and nearby, *Ixia flaccida* grows on seasonally moist, south-facing, sandy, or sometimes light, loamy clay slopes, among rocks usually in the shade of shrubs and small trees (Figure 8).

Diagnosis and variation: the flowers of *Ixia flaccida* are relatively small, with tepals \pm 14 \times 3.4–4.5 mm, perianth tube 7–9 mm long, and anthers \pm 2.5 mm long. The tunics of medium-textured to fine fibres and the \pm linear or narrowly sword-shaped, soft-textured leaves, as well as the white or pale blue flowers, readily distinguish the species from typical *I. rapunculoides*, which has blue to blue-mauve or sometimes pink flowers with a yellow cup.

In addition to the Olifants River Valley collections that closely match the type of *I. rapunculoides* var. *flac-*

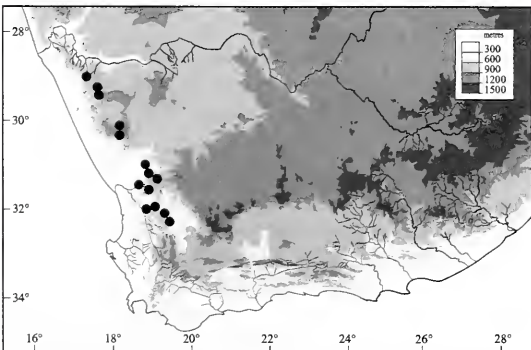


FIGURE 7.—Known distribution of *Ixia namaquana*.

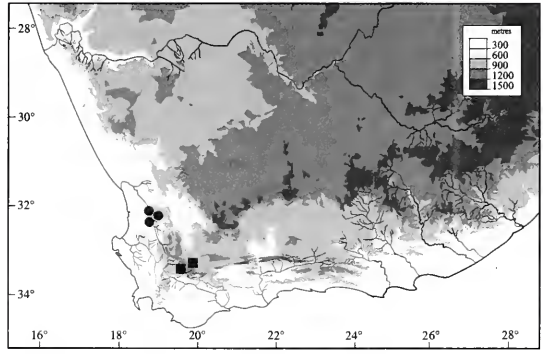


FIGURE 8.—Known distribution of *Ixia flaccida*, ●, *I. oxalidiflora*, ■.

cida, Lewis (1962) included pink-flowered plants from the Bokkeveld Plateau and white-flowered plants from the Little Karoo in the taxon. As outlined above, we regard the Bokkeveld plants as *I. sobolifera* subsp. *carnea* and the Little Karoo plants as *I. sobolifera* subsp. *albiflora*. Both differ from var. *flaccida* in their corms, which have soft-textured, short-lived tunics and produce long, ribbon-like stolons. They also differ in some floral features, notably the longer bracts, 6–10 mm long (vs 5–6 mm long in *I. flaccida*) and, in subsp. *carnea*, a longer perianth tube 9–10 mm long and longer anthers 3–4 mm long.

The earliest record we have found of the species is the collection made by P.A. Mader near Clanwilliam, \pm 1874. A later collection made by Rudolf Schlechter in 1894 is from an unlikely locality, near Porterville, that requires confirmation. These collections and the few made later were referred to *Ixia rapunculoides* until 1962 when Lewis (1962) chose a second Schlechter collection, made in 1896, from Boschkloof [Boschkloof] east of Clanwilliam, as the type of her new *I. rapunculoides* var. *flaccida*.

Selected specimens

WESTERN CAPE.—3218 (Clanwilliam): Clanwilliam, (–BB), without date, Mader 193 (K), August 1905, H. Bolus 10619 (BOL); near Clanwilliam Dam, (–BB), July 1948, Lewis 1981 (SAM); 9 miles [21 km] S of Clanwilliam, damp slopes above road, (–BB), 26 August 1957, Lewis 5210 (NBG); N of Citrusdal at Marcuskraal turnoff, sandy, S-facing bank, (–BD), 31 August 2005, Goldblatt 12678 (MO, NBG). 3219 (Wuppertal): Cedarberg, Langrug Farm, moist sand in shade, (–AC), 21 August 1982, Viviers 508 (PRE). Doubtful locality: 3218 (Clanwilliam): sandy places near Porterville, 240 m, (–DD), 20 August 1894, Schlechter 4913 (MO, PRE).

8. *Ixia oxalidiflora* Goldblatt & J.C.Manning, sp. nov.

Plantae 200–450 mm altae, cormo 6–8(–10) mm diam. stolonifero, tunicis fibrosis tenuibus, foliis 3, inferioribus 2 anguste ensiformibus 6–12(–15) mm latis, spica 2–4-flora, floribus pallide purpureo-carneis cupula alba, inodoris, tubo perianthii 16–22 mm longo, tepalis subaequalibus 14–18 \times 6–7 mm, filamentis \pm 4 mm longis, antheris \pm 3.5 mm longis in tubo inclusis, stylo bases antherarum adversus dividenti, ramis \pm 1 mm longis.

TYPE.—Western Cape, 3319 (Worcester): Hex River Pass, south-facing clay slopes, (–BC), 2 September 1992, Goldblatt & Manning 9397 (NBG, holo.; MO, iso.).

Plants 200–450 mm high. *Corm* 6–8(–10) mm diam., with broad, compressed stolons, tunics of fine netted fibres, soon decaying. *Leaves* 3, lower 2 narrowly sword-shaped to linear, fairly soft-textured, 6–12(–15) mm wide, attenuate, uppermost leaf sheathing stem, margins straight and not thickened. *Stem* usually with 1 or 2 filiform, twisted lateral branches up to 12 mm long. *Main spike* 2–4-flowered, lateral spikes 1 or 2-flowered; bracts translucent, outer with 3 dark veins, 10–12 mm long, with 3 subequal acuminate tips, inner with 2 dark veins and forked at apex. *Flowers* ascending to \pm upright, purple-pink with \pm white cup, unscented; perianth tube 16–22 mm long, funnel-shaped; tepals subequal, ovate, 14–18 \times 6–7 mm, spreading at right angles to tube in distal 10–12 mm. *Stamens* parallel; filaments erect, \pm 4 mm long, inserted 8–10 mm above base of tube; anthers \pm 3.5 mm long, included in tube, tips reaching up to 0.5–2.0 mm below mouth of tube. *Style* dividing opposite middle of anthers, branches \pm 1 mm long, extending between anthers. *Capsules* and *seeds* unknown. *Flowering time*: mid-August to mid-September. Figure 6E–G.

Distribution: *Ixia oxalidiflora* is currently known from two sites, the top of Hex River Pass, and near Tweedside Station, \pm 60 km to the east (Figure 8). It favours south-trending slopes and clay or loamy soils, where it typically grows wedged in crevices of shale outcrops. The purple-pink flowers with a white cup (the latter sometimes described as pale yellow) closely resemble in shape and colouring those of co-occurring *Oxalis heterophylla* (Oxalidaceae) which blooms at the same time.

Diagnosis and variation: the earliest record of the species that we have traced is one made by F.A. Rogers in 1915. Early collections of *Ixia oxalidiflora* were referred to *I. rapunculoides* var. *namaquana* without comment by Lewis (1962) and De Vos (1999), although these specimens equally resemble similarly large-flowered *I. pauciflora* G.J.Lewis in general aspect. Careful examination of the flowers, however, shows that they differ markedly from both taxa in having the stamens fully included in the perianth tube, with the anther tips reaching 0.2–0.5 mm below the tube apex, and a perianth tube 16–22 mm long. In *I. namaquana*, only the filaments and bases of the anthers are included in the tube, which is shorter, mostly 13–16 mm long, and in *I. pauciflora*, the tips of the filaments are typically exerted from the tube. The corms, which have soft-textured tunics and long stolons, resemble neither species, and the lanceolate, soft-textured leaves are quite different to the linear, very narrow, firm leaves of *I. pauciflora* or the broader, leathery leaves of *I. namaquana*. *Ixia oxalidiflora* is thus recognized by the combination of fully included stamens, a perianth tube 16–22 mm long, soft-textured leaves, 6–12(–15) mm wide, and the small corms that bear long, flat stolons. The flowers are also held upright, a feature only apparent when plants are seen alive, thus unlike the horizontal flowers of *I. namaquana* and *I. pauciflora*.

Selected specimens

WESTERN CAPE—3319 (Worcester): Hex River Pass, south-facing shale slopes, (–BC), 13 September 2005 (late flowering), Manning & Goldblatt 2992 (MO, NBG), 1 September 1963, Hardy 48 (BOL, K, PRE); below summit of Hex River Pass, SE slopes on shale, 625 m, (–BC), 16 September 1974, Maive & I. Oliver 152 (NBG, PRE); between Osplaats and Tunnel Sidings, (–BC), August 1915, Rogers

16743 (BOL). 3320 (Montagu): hill approx. 2 km W of Tweedside Station, in loam among rocks, 1 200 m, (–AB), 12 August 1988, Vlok 1989 (NBG, PRE); south-facing slopes of Memorial hill above cemetery, in light clay, (–AB), 31 Aug. 2007, Goldblatt & Porter 12924 (K, MO, NBG, PRE).

9. *Ixia divaricata* Goldblatt & J.C.Manning, nom. nov., pro *I. latifolia* var. *angustifolia* G.J.Lewis in Journal of South African Botany 28: 86 (1962). Type: South Africa, [Western Cape] Witzenberg, middle east face opposite Farm Rosendal, 26 November 1941, N.S. Pillans 9790 (BOL, holo.).

I. scariosa var. *longifolia* Baker: 165 (1892), in part. Types: South Africa, [Western Cape], near Ceres, October 1873, H. Bolus 2621 (K!, BOL!, SAM!); Avontuur, H. Bolus 2487 (BOL!, lecto., designated by De Vos (1999), K!, = *I. orientalis* L.Bolus).

I. rapunculoides var. *rigida* G.J.Lewis: 77 (1962), syn. nov. Type: South Africa, [Western Cape], Hex River Valley, 1 October 1893, P. MacOwan in Herbario Normale Austro-Africana 1653 (BOL! [as Hex River Pass, Bolus s.n. in Guthrie 3077], G, K! [as near Hex River East, 1500' (\pm 460 m)], MO! [as Hex River Valley, De Doorns, Oct. 1893, H. Bolus s.n.], SAM!, Z).

I. rapunculoides var. *subpendula* G.J.Lewis: 77 (1962), syn. nov. Type: South Africa, [Western Cape], between Groot River and Elands Kloof, Oct. 1939, C.L. Leipoldt 3026 (BOL, holo.).

Plants 300–500 mm high. *Corm* subglobose, tunics of medium-textured, netted fibres, bearing 1–few sessile cormlets at base. *Leaves* 3–5, lower 2–4 narrowly sword-shaped to linear, (1.5–)3.0–5.0 mm wide, margins moderately thickened, hyaline when dry, straight, usually about one third to half as long as stem, uppermost 1 or 2 leaves sheathing stem. *Stem* with (1–)3 straight lateral branches mostly held at 30–45(–50) $^\circ$ to main axis, filiform, bearing flowers in upper half. *Main spike* 4–7-flowered, lateral spikes (1–)3–5-flowered; bracts translucent, outer with 3 dark veins, mostly 6–7 mm long, inner with 2 dark veins and forked apically. *Flowers* upright, whitish or pale to deep pink or light purple with pale yellow cup, unscented or with faint sweet scent; perianth tube funnel-shaped, 8–11 mm long; tepals subequal, 11–14 \times 5.5–7.0 mm, proximal 3–4 mm forming part of floral cup, subpatent. *Stamens* parallel; filaments 4–5 mm long, distal 1–2 mm exerted from tube, rarely reaching only to top of tube, inserted \pm 5 mm above tube base; anthers 4.0–5.5 mm long, fully exerted from tube, tips exerted from floral cup. *Style* dividing opposite middle of anthers, branches 1–2 mm long, extending between anthers. *Flowering time*: from late August at low elevations to October, November and December at higher elevations. Figure 9.

Distribution: *Ixia divaricata* is scattered through the mountains of the southwestern Cape, from Elandskloof, east of Citrusdal in the southwestern Cedarberg, through the Cold Bokkeveld to Ceres and Tulbagh (Figure 10). Plants favour seasonally wet, stony sandstone flats and rocky sites.

Diagnosis and variation: *Ixia divaricata* is unmistakable in its unusual, divaricate branching pattern, with distinctive, stiff, straight lateral branches held at angles of 30–50 $^\circ$ to the main axis and bearing mostly 3–5 flowers crowded in the distal half. The white or pink, or really purple flowers are held erect, with the tepals loosely spreading but not fully patent. Why this plant was treated as var. *subpendula* of *I. rapunculoides* is puzzling for not only is it distinctive in its branching pattern but the flow-

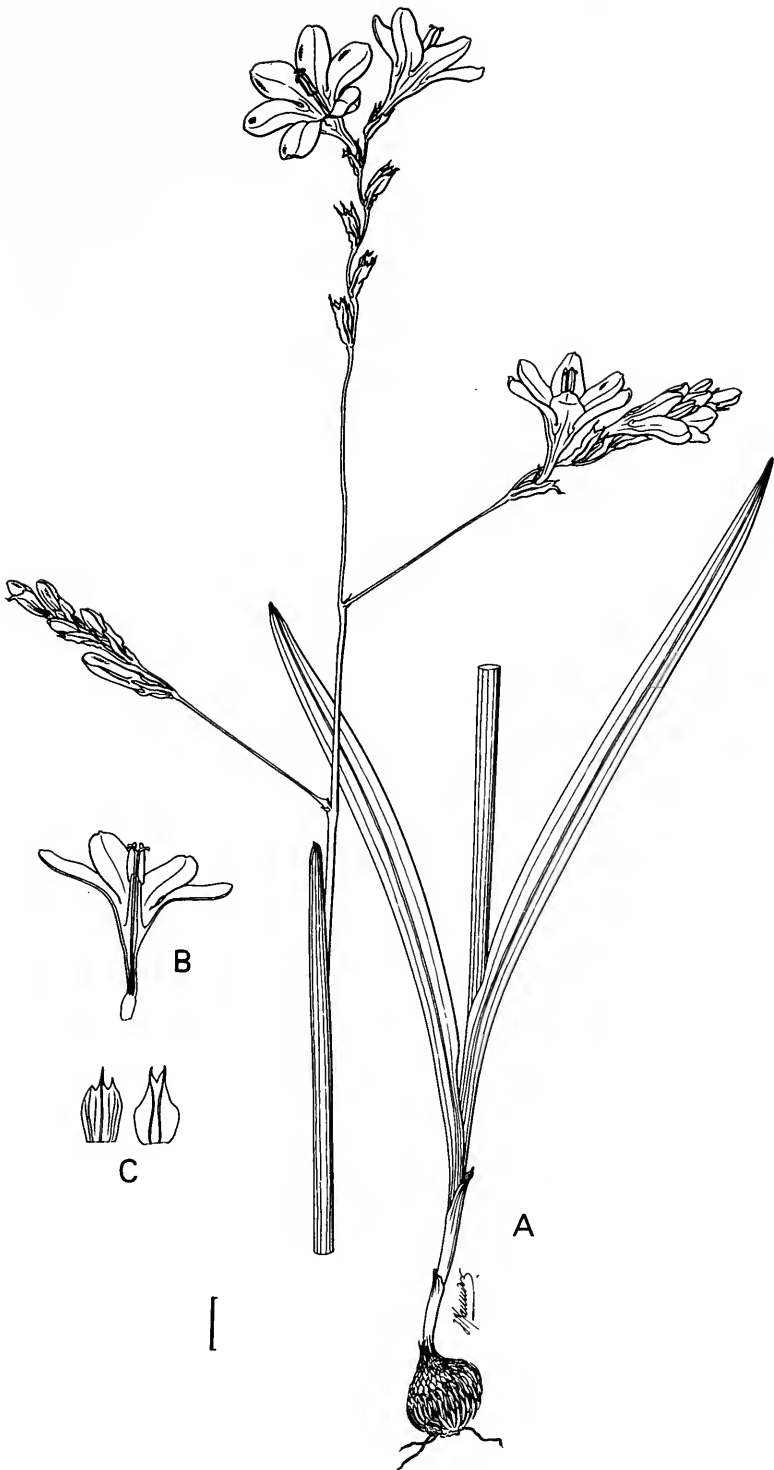


FIGURE 9.—*Ixia divaricata*, Goldblatt & Porter 12610 (MO, NBG). A, whole plant; B, 1/5 flower; C, bracts: outer (left), inner (right). Scale bar: 10 mm. Artist: J.C. Manning.

ers are upright, not horizontal, and the anthers, 4.0–5.5 mm long, are usually fully exserted from the tube or rarely have their bases included. Specimens with anthers exserted 1–2 mm were often included in *I. latifolia* by De Vos (1999) but true *I. latifolia* has larger, deep pink

flowers with a perianth tube 14–17 mm long, filaments \pm 10 mm long, and broad basal leaves, mostly 10–18 mm wide. We regard var. *subpendula* as a separate species, which we name *I. divaricata* for the divaricate branching pattern. Although valid synonyms at varietal rank

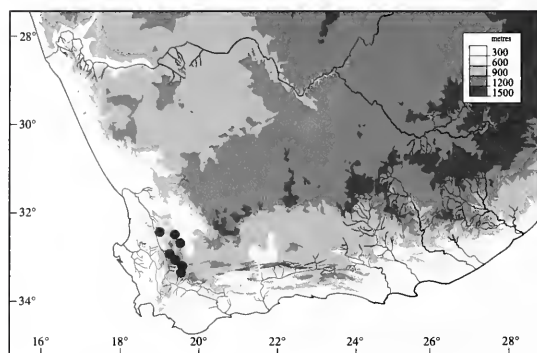


FIGURE 10.—Known distribution of *Ixia divaricata*.

exist for the species (see above), we have chosen the new name *divaricata* at species rank. The name *I. angustifolia* is preoccupied in the genus by *I. angustifolia* (Andrews) Klatt (1895), a later synonym of *I. monadelphica* (Lewis 1962). We prefer not to use the epithets *subpendula* (based on *I. latifolia* var. *subpendula*) or *rigida* (based on *I. rapunculoides* var. *rigida*) for the species because the former is misleading and the latter is based on an atypical type specimen.

The immediate relationships of *Ixia divaricata* are most likely with *I. latifolia*. Confusion with that species is due in part to some longer-tubed collections with the tube 12–14 mm long (e.g. *De Vos* 2693 and *Leipoldt* 4070) that also have relatively short, broad leaves, up to 18 mm wide (a feature of *I. latifolia*) but fairly slender branches (characteristic of *I. divaricata*). These are almost certainly hybrids between the two species, which grow within sight of one another, although always on different soils, *I. latifolia* favouring heavy clay or loam.

Ixia divaricata was associated historically with *I. latifolia*, and one of the two specimens cited by Baker (1892) under var. *longifolia* of *I. scariosa*, the name by which *I. latifolia* was then known (the other specimen is *I. orientalis* and is the lectotype of the name) is *I. divaricata*. Although the type of *I. latifolia* var. *angustifolia*, from the Witzenberg is *I. divaricata*, several other specimens assigned here by Lewis (1962) and De Vos (1999) are a different species, *I. monticola*, which we describe elsewhere (Goldblatt & Manning in prep.). Although these two taxa have been confused in the literature they may not be particularly closely allied. The most important differences are that *I. monticola* has a corm with membranous, non-accumulating tunics, few or no branches, and four or five leaves. *I. divaricata*, in contrast, has fibrous tunics of medium texture and a distinctive branching pattern, and plants from high elevations typically have two or three leaves in most specimens, although sometimes more in those from middle elevations.

Another synonym may be *Ixia stellata* (Andrews) Klatt (1882), based on *I. capitata* var. *stellata* Andrews (1802), but the quality and detail in the painting on which the taxon must be based makes a firm identification impossible and no preserved material has been found at K and BM, the herbaria where they would most likely have been preserved.

We also include the type of *Ixia rapunculoides* var. *rigida* from the Hex River Valley in *I. divaricata*, which it closely resembles in the relatively long straight branches with distally crowded flowers, unlike the remaining specimens assigned to var. *rigida*, which have shorter, flexuose, horizontal branchlets and flowers evenly spaced along their length. This collection is the only record from the Hex River Valley, where we assume it no longer occurs as a result of intensive viticulture there. *Ixia divaricata* is still common in the Cold Bokkeveld, where it is found in sites presently protected from agriculture, although below Gydo Pass in the Warm Bokkeveld, it is now threatened by the expansion of orchards from Ceres and Prince Alfred's Hamlet to the foot of the Pass.

Provisionally we also include in *Ixia divaricata* plants from upper Moraine Kloof in the Hex River Mountains (*Helme* 2864), flowering in January. They have a similar branching pattern but somewhat smaller, purple flowers with a tube ± 5 mm long, tepals ± 10 mm long, and anthers ± 3.2 mm long. The style divides at the top of the anthers and has branches ± 1.3 mm long that extend above the anther tips, whereas in typical *I. divaricata* the style divides opposite the middle of the anthers. Unfortunately, the specimens lack corms and leaves without which a fair decision about the status of this plant, flowering some two months after other collections of *I. divaricata*, cannot be made.

Pollination of *Ixia divaricata* accords with that for other species of the *I. rapunculoides* complex. At our study site for the species at Waboomsriver in the Cold Bokkeveld, flowers were visited and presumably pollinated by a range of medium-sized and large bees including *Lasioglossum* sp. (Halictidae) and *Anthophora diversipes* and *Amegilla spilostoma* (Apidae).

Selected specimens

WESTERN CAPE.—3219 (Wuppertal): Cedarberg, valley between Sneeuwberg and Tafelberg, wet sandy flats, (–AC), 19 October 1923, *Pocock* 408 (NBG); Elands-kloof, Ceres, (–CA), 30 September 1944, *Barker* 3094 (BOL, NBG); Cold Bokkeveld, Waboomsriver, sandy vlakke, (–CC), 4 October 1966, *Hanekom* 776 (K, PRE); Cold Bokkeveld, 3 miles S of Leeuwrivier, (–CD), September 1952, *Lewis* 2512 (PRE, SAM). 3319 (Worcester): Great Winterhoek, Sneeuwgat, (–AA), November 1916, *Phillips* 1874 (NBG); Steindaal, Tulbagh, October–November 1858, *Pappe s.n.* SAM20937 (NBG); Tulbaghskloof (Neuwekloof), Tulbaghsthal, foot of the Winterhoekseberg, Witsenberg and Vogelvallei, (–AA), November 1830, *Ecklon & Zeyher Irid.* 94 (BOL, K, PRE); Cold Bokkeveld, roadside at Farm Wadriif, in rocky sandstone ground, (–AB), 30 September 2004, *Goldblatt & Porter* 12604 (MO, NBG); Schurfrdeberg Pass, wet place, (–AB), 30 October 1950, *Compton* 22277 (NBG); stony flats at the foot of Gydo Pass, (–AB), 4 October 2004, *Goldblatt & Porter* 12610 (MO, NBG, PRE); Witsenberg, Visgat Valley, Farm Wakkerstroom, (–AC), 5 November 2003, *Low* 9376 (NBG); near Ceres Nature Reserve in wet ground, (–AD), 8 October 1986, *De Vos* 2675 (NBG, PRE); top of Michell's Pass, (–AD), without date, *Marloth* 10692 (PRE); Matroosberg, near Lakenvlei, (–AD), without date, *Phillips s.n.* SAM11876 (NBG); Ceres, Schoonvlei Industrial Area, (–AD), 28 September 1987, *Cloete & Cillie* 103 (NBG, PRE); Hex River Mtns, upper Moraine Kloof Amphitheatre south of Milner Peak, 1 050 m, (–AD), 4 January 2004, *Helme* 2864 (NBG).

Putative hybrids with *Ixia latifolia*: 3319 (Worcester): Ceres, Gydwou, (–AB), 3 October 1942, *Leipoldt* 4070 (PRE); between Ceres and Hottentotskloof, on Conradie farm, (–AD), 18 September 1987, *De Vos* 2693 (PRE).

10. *Ixia contorta* Goldblatt & J.C.Manning, sp. nov.

Ixia rapunculoides var. *rigida* sensu G.J.Lewis: 77 (1962), but excluding the type.

Plantae (70–)100–300 mm altae, cormo subgloboso 10–14 mm diam. tunicis fibrosis duris nigrescentibus persistentibus, foliis 3 inferioribus 2 anguste ensiformibus vel falcatis (2)3–5 mm latis marginibus moderate incrassatis, caule 1–3-ramoso, ramis contortis, spica flexuosa inclinata vel subhorizontali, 2–6 flora, floribus purpureis cupula flava, tubo perianthii 9–13 mm longo, tepalis subaequalibus 9–12 × (4.5–)6.0–8.0 mm, filamentis ± 3 mm longis in tubo inclusis, antheris 3–4 mm longis.

TYPE.—Western Cape, 3219 (Wuppertal): Cold Bokkeveld, low hill east of Farm Waboomsrivier, well-drained sandy ground, (–CD), 17 September 2006, Goldblatt & Porter 12854 (NBG, holo.; MO, PRE, iso.).

Plants (70–)100–300 mm high. *Corm* subglobose, 10–14 mm diam., with tunics of medium-textured to fine, dark, wiry, netted fibres, bearing 1–few sessile cormlets at base. *Leaves* 3, lower 2 linear to narrowly sword-shaped or falcate, (2–)3–5 mm wide, margins and midrib moderately thickened, straight, about one third as long as stem, uppermost leaf sheathing lower half of stem. *Stem* suberect, usually with 1–3 short, twisted branchlets mostly held at 60–90° to main axis. *Main spike* conspicuously flexuose, bent at base and inclined to ± horizontal, 2–6-flowered, lateral spikes 1–6-flowered; bracts translucent, often flushed brown or purple, outer with three dark veins, mostly 7–9 mm long, bluntly 3-lobed apically, inner with two dark veins and forked apically. *Flowers* upright, purple (or said to be blue) with a yellow cup sometimes edged with a band of dark purple, unscented; perianth tube funnel-shaped, 9–13(–14) mm long; tepals subequal, 9–12 × (4.5–)6.0–8.0 mm. *Stamens* parallel; filaments ± 3 mm long, included, inserted 4–5 mm above base of tube; anthers 3–4 mm long, lower half to one third included in tube. *Style* dividing opposite middle of anthers, branches ± 1 mm long, extending between anthers. *Flowering time*: mid-September to October. Figure 11.

Distribution: *Ixia contorta* is centred in the Cold Bokkeveld but extends north to the Cedarberg and east to Touws River, growing in well-drained, sandy ground (Figure 12).

Diagnosis and variation: treated by Lewis (1962) as *Ixia rapunculoides* var. *rigida*, this plant from the interior Western Cape mountains is recognized among those species with included filaments by the markedly flexuose spikes and by the main axis strongly flexed below the first flower, thus inclined to nearly horizontal. The purple flowers (also sometimes described as blue or lilac) have a yellow cup sometimes edged in dark purple, and are held upright on the spikes, unique among the species with included filaments and anthers held partly within the perianth tube. The perianth tube is 9–13(–14) mm long and the tepals are 9–12 mm long. The very different appearance of the flowers suggests that these plants are not immediately allied to *I. rapunculoides* and we not only regard them as representing a separate species, but

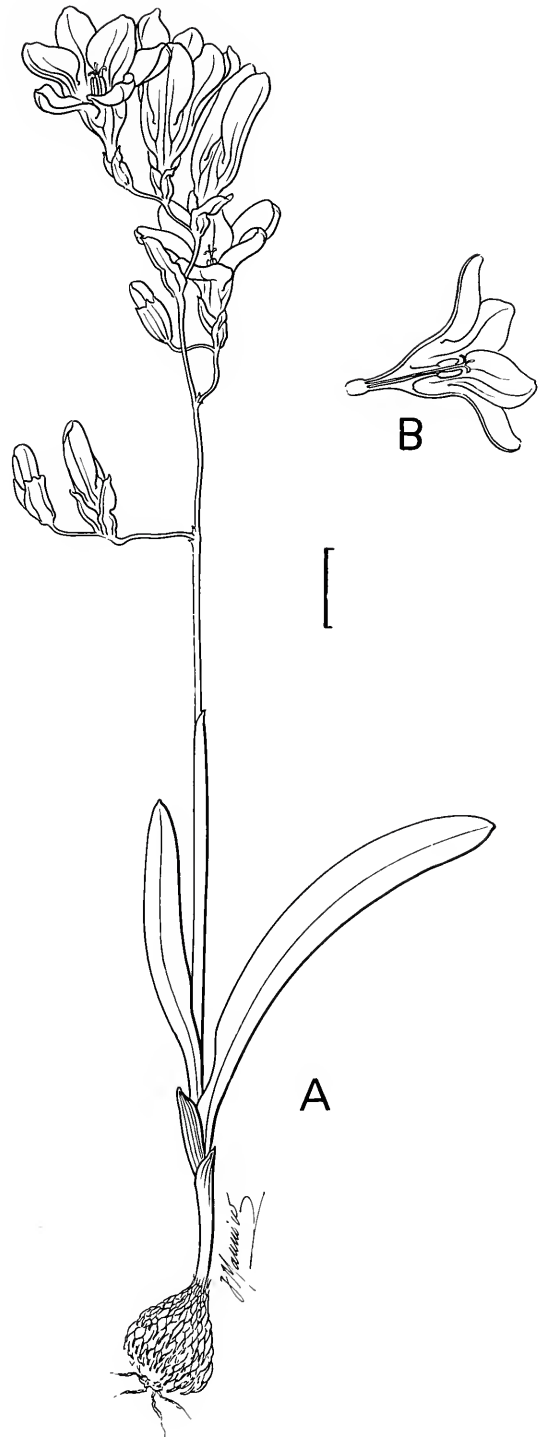


FIGURE 11.—*Ixia contorta*, Goldblatt & Porter 12854 (MO, NBG). A, whole plant; B, 1/5 flower. Scale bar: 10 mm. Artist: J.C. Manning.

question their relationship to the complex. We describe this plant here as *I. contorta*, so named for the twisted lateral branchlets and flexuose spike, a feature particularly well-developed in this species. The new name

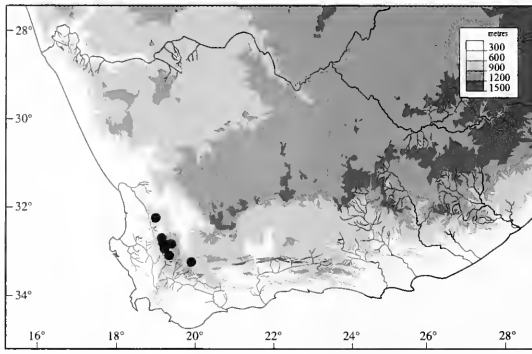


FIGURE 12.—Known distribution of *Ixia contorta*.

is required because the type of var. *rigida* is *I. divaricata* (see synonymy of the latter species). *Ixia contorta* can be distinguished from *I. divaricata* by the short, twisted branchlets, quite different from the long, straight branches of *I. divaricata*, the flowers of which are white to pale pink, rarely purple, and the filaments are usually shortly excluded from the tube.

Plants are usually fairly short, seldom exceeding 150 mm, but collections from Gydo Pass (e.g. *Leipoldt* 3023) are taller, some reaching 300 mm. Typical *Ixia contorta* has also been collected on Gydo Pass, which indicates to us that the taller plants with narrow leaves are not simply a local variant of the species. We suspect they are hybrids, the result of crossing with *I. divaricata*, which also grows there. The longer, narrower leaves, paler flower colour and slightly larger perianth in these plants may also reflect the influence of genes of *I. divaricata*.

Plants from the north of the range near Alberta Farm, and in the Matjiesrivier Valley in the Cedarberg stand out in having a longer perianth tube, 12–13 mm in *Nänni* 81, and 12–14 mm in *Gillett* 4108. The latter plants, also exceptional in their slightly wider perianth tube, were referred to *I. rapunculoides* var. *rigida* by Lewis (1962) but evidently puzzled De Vos (1999), who identified a duplicate of the *Gillett* collection at PRE as *I. rapunculoides* var. *namaquana* (i.e. *I. namaquana*). The latter taxon differs particularly in having flowers facing to the side, rather than upright, longer floral bracts, and a straight and erect rather than flexuose, inclined spike axis. The broad leaves, up to 10 mm in one plant of the *Gillett* collection, are exceptional for *I. contorta* and it remains possible that the gathering represents a novelty. Additional collections of *I. contorta* from the north of its range are needed to better assess the variation in the species.

Selected specimens

WESTERN CAPE.—3219 (Wuppertal): Clanwilliam, 2 miles [3.2 km] from top of Uitkyk Pass in Matjies River Valley, (–AC), 9 October 1938, *Gillett* 4108 (BOL, K, PRE); Cold Bokkeveld, Farm Onverwaght on road to Alberta, (–BA), 14 October 1994, *Nänni* 81 (MO); Ceres District, Luiperdskloof 4x4 route near Bloukop, 1 350 m, (–CB), 13 September 2002, *Steyn* 174 (PRE); Koue Bokkeveld, Farm

Bokkenfontein, sandy flats near Leeu River, flowers blue, (–CC), 16 September 1976, *M. Thompson* 2953 (NBG, PRE); Cold Bokkeveld, Farm Houdenberg, 850 m, (–CD), 13 October 1921, *Marloth* 10613 (PRE). 3319 (Worcester): Gydouw Pass, (–AB), October 1926, *Marloth* 12965 (PRE); Gydouw, (–AB), September 1941, *Leipoldt* 3821 (BOL); Cold Bokkeveld, between Loch Lynne and Winkelhaak, sandy flats, (–AB), 11 October 1974, *Oliver* 5122A (NBG, PRE). 3320 (Montagu): Touws River, sandstone koppie, (–AC), September 1924, *Levy* 858 (BOL); dry sandy flats W of Touws River, (–AC), 27 September 1924, *Rennie s.n.* (BOL).

Putative hybrids with *Ixia divaricata*: 3319 (Worcester): Ceres, Gydouw, (–AB), October 1939, *Leipoldt* 3023 (BOL, K, NBG, PRE, SAM).

ACKNOWLEDGEMENTS

Support for this study by grants 7103-01 and 7799-05 from the National Geographic Society is gratefully acknowledged. Collecting permits were provided by the Nature Conservation authorities of Northern Cape and Western Cape, South Africa. We thank Ingrid Nänni and Lendon Porter for their assistance and companionship in the field and C.D. Michener for identifying bees collected during our study.

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Three new species of *Asparagus* (Asparagaceae) from South Africa, with notes on other taxa

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Keywords: Asparagaceae, *Asparagus* L., South Africa, taxonomy

ABSTRACT

Three new species of *Asparagus* L. are described from South Africa: *Asparagus elephantinus* S.M.Burrows, *A. hirsutus* S.M.Burrows and *A. sylvicola* S.M.Burrows; and the past confusion between *Asparagus acockii* Jessop and *A. lynetteae* (Oberm.) Fellingham & N.L.Mey. is discussed.

INTRODUCTION

Species within the genus *Asparagus* are notoriously difficult to identify. The plants are unappealing to collect, and when collected, not enough attention is paid to the plant's habit, and especially the rooting system. In many instances not enough material is collected, making the identification of the plants difficult. During extensive field research and herbarium work for a taxonomic revision of the genus in southern Africa, a number of undescribed taxa have been noted, and the distribution of several species has been extended. Type localities have been revisited wherever possible, and material has been collected from the type locality or as close to the locality as possible for each taxon. This has been done to ensure that the correct concept of the taxa is understood.

Since the Buffelskloof Herbarium has yet to attain an international herbarium acronym, the temporary abbreviation BNRH will be used throughout.

***Asparagus elephantinus* S.M.Burrows, sp. nov.**, *A. densiflori* similis sed caulis longissimis validis, ramis ramulisque longis, tuberibus rotundis vel late ellipsoideis, spinis validis, pedunculo infra medio articulo, fructu maiori differt.

TYPE.—Limpopo, 2430 (Pilgrim's Rest): above J.G. Strydom Tunnel, Abel Erasmus Pass, R36, Ohrigstad, (–BC), 8 January 2005, J.E. Burrows & Lotter 8781 (PRE, holo.; BNRH, iso.).

Scrambling, multistemmed shrub, evergreen, usually shallow-rooted, not twining, glabrous throughout. *Rhizome* small; roots terete, up to 8 mm diam. with numerous side rootlets; lateral tubers off thick main roots, round to broadly ellipsoid, 30–51 × 22–40 mm. *Stems* robust, 10–15 mm thick, up to 3 m long, bright green, completely glabrous, faintly ribbed towards base. *Spines* large on stems, up to 20 mm long, smaller elsewhere, hard, sharp, straight to curved downwards, pale orange brown; present below branches, branchlets, cladode fascicles and flowers. *Leaf scales* on stem triangular, 1.0–5.5 mm long, very pale with darker median stripe,

margins entire, depauperate to absent on branches and branchlets. *Branches* spreading, up to 0.6 m long, faintly papillose-ribbed. *Branchlets* spreading, up to 150 mm long, distinctly papillose-ribbed, 5-angled, slightly zig-zagging. *Cladodes* 1–3(–6) per fascicle, held at an angle to branches, flattened, narrowly elliptic to linear, (5–)8–25(–31) × 1.5–2.0 mm long, bright green, glossy, base constricted with a basal foot, margins papillose. *Racemes* 50–70 mm long, arising from branch or branchlet nodes, simple or branched, an occasional cladode sometimes present. *Flowers* 1–3 per fascicle, sweetly scented. *Pedice*l 1.5–3.0 mm long, articulated in lower half. *Tepals* 6, 3.0–4.2 × 1.5–1.9 mm, apex curved inwards, margin entire. *Stamens* 6; filaments 2.25–2.65 mm long, fused length 0.75 mm, free length 1.5–1.9 mm; anthers orange. *Style* 0.4–0.5 mm long; stigma 3-fid, arms 0.1–0.2 mm long. *Ovary* oblong-ellipsoid, trilocular, 1.8–3.0 × 1.1–2.0 mm. *Fruit* a berry, 2- or 3-lobed, 10–14 mm diam., glabrous, red when ripe. All measurements of cladodes, leaf scales, flowering and fruiting parts taken from pickled specimens. *Flowering time*: January to February. Figure 1.

Distribution and habitat: *Asparagus elephantinus* is currently known from the Olifants River Valley of Limpopo Province, from Penge to the Abel Erasmus Pass (Figure 2), where it occurs mainly on dolomite or the quartzitic outcrops adjacent to the dolomite formations. This very robust plant, with 3 m long stems, grows on rocky ledges, or among rocks in leaf litter. It is principally confined to vegetation type SVcb 25, Pong Dolomite Mountain Bushveld (Mucina & Rutherford 2006). This asparagus is widespread in its area, and is well protected since it favours rocky ledges and inaccessible cliff faces. It is surprising that such a large species of *Asparagus* has remained undetected for so long in such a well-visited area as the Abel Erasmus Pass.

Diagnostic characters and affinities: *Asparagus elephantinus* is similar to *A. densiflorus* (Kunth) Jessop in that they both have flattened cladodes, with both the cladodes and branches clearly papillate-ribbed. However, *A. elephantinus* differs from *A. densiflorus* (Table 1).

Etymology: *Asparagus elephantinus* is named after the Olifants River Valley, to which it is currently confined; in addition, the name highlights the large size of the plant.

* Buffelskloof Nature Reserve Herbarium, P.O. Box 710, 1120 Lydenburg, South Africa.
MS. received: 2007-06-20.

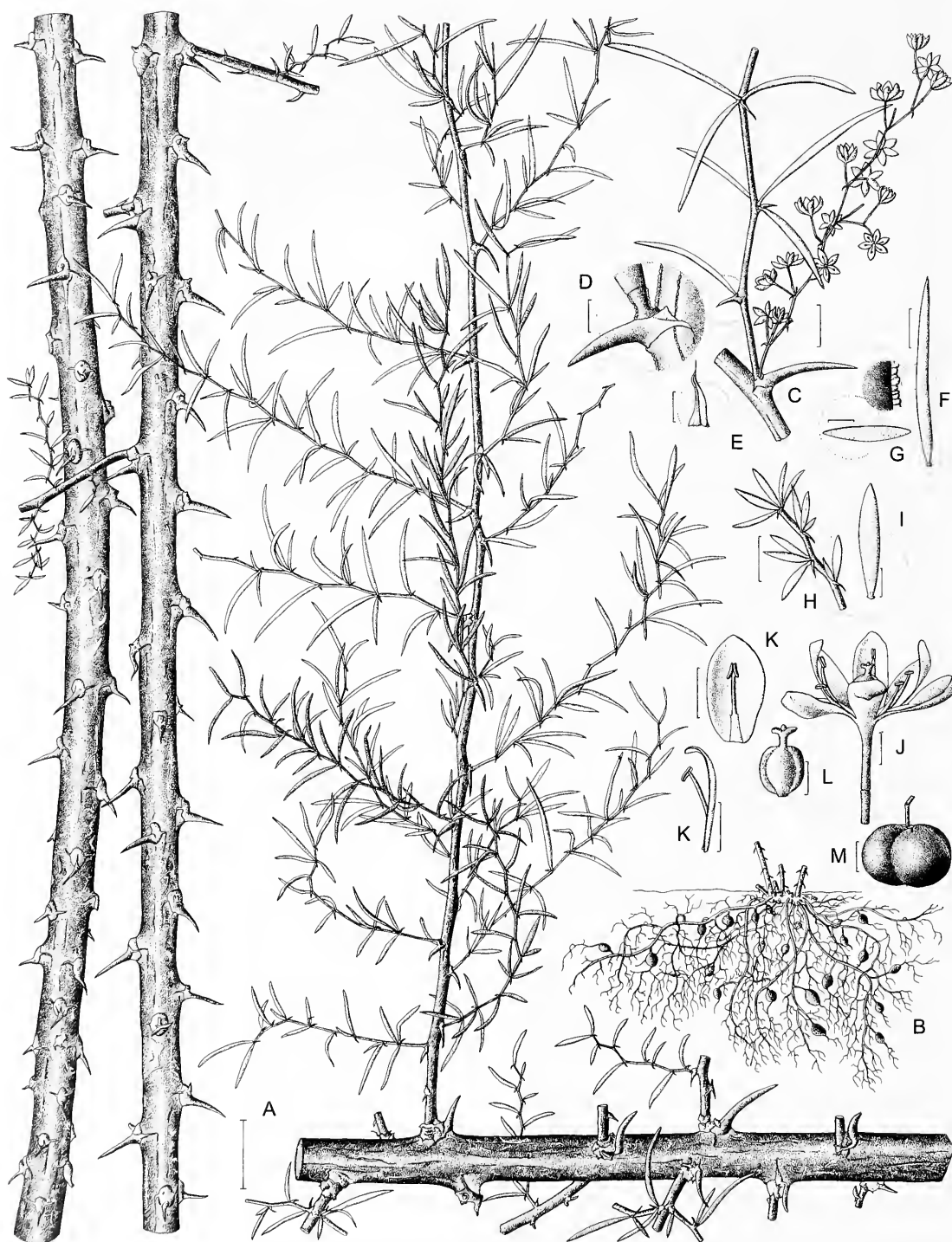


FIGURE 1.—*Asparagus elephantinus*, A–G, J–M, J.E. Burrows & Lotter 8781; H, I, J.E. & S.M. Burrows 9034. A, stem and first branch; B, rhizome habit; C, raceme; D, cladode base; E, leaf scale; F, cladode and margin enlargement; G, c/s cladode; H, I, cladodes. J–L, floral details: J, flower; K, stamen and tepal; L, ovary. M, fruit. Scale bars: A, 12.2 mm; C, F, 3.7 mm; D, 0.3 mm; E, 1.5 mm; G, 0.46 mm; H, 4.9 mm; I, 1.2 mm; J, K, 0.9 mm; L, 0.6 mm; M, 2.4 mm. Artist: Sandra Burrows.

Specimens examined

LIMPOPO.—2430 (Pilgrim's Rest): pass W of Penge on road to Chuniesspoort, 1 200 m, (–AC), 6 March 2005, J.E. & S.M. Burrows 8914 (BNRH); N bank of Olifants R. near new bridge, Penge Mine,

800 m, (–AD), 11 November 2002, J.E. Burrows & M.C. Lotter 7878 (BNRH, PRE); ± 4 km N of Penge, next to Olifants R., 600 m, (–AD), 13 November 2005, J.E. & S.M. Burrows 9304 (BNRH); just above J.G. Strydom Tunnel, Abel Erasmus Pass, 679 m, (–BC), 28 August 2002, J.E. & S.M. Burrows 7770 (BNRH, PRE).

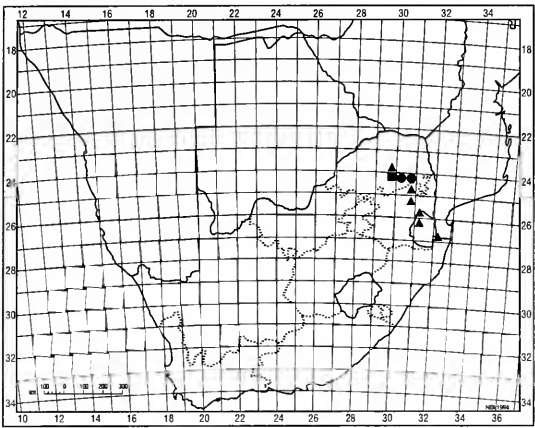


FIGURE 2.—Known distribution of *Asparagus elephantinus*, ●; *A. hirsutus*, ■; and *A. sylvicola*, ▲.

Asparagus hirsutus S.M.Burrows, sp. nov., *A. capensi* var. *capensi* similis sed tuberibus ellipsoideis, ramis non spinescentibus, pilis omnino albis et squamis foliosis glabris differt; *A. minutiflori* similis sed pilis omnino albis, margine squamarum foliosarum integra et pedicello hirsuto in parte superiore articulo differt.

TYPE.—Limpopo, 2429 (Zebedelia): Atok Platinum Mine, Zeekoegat Farm, Monametse Village, east of mineshaft, hill slope, 816 m, (–BD), 16 November 1999, L.M.D. Riddles 511 (PRE, holo.; BOL, BNRH,J, KEW, PRU, UNIN, iso.).

Erect, multistemmed, compact, very hairy, evergreen shrublet of foxtail form, olive to grey-green, 300–500 mm high. *Rhizome* woody; roots 0.1–5.5 mm diam.; with a few lateral ellipsoid tubers present, 36–40 × 14–21 mm; cataphylls present. *Stems* 1.2–5.0 mm thick, faintly ribbed, pale, terete, covered in white hairs, skin peeling in patches in older specimens to smooth below. *Spines* 1.2–6.0 mm long, straight, thin, facing sideward or downward, hairy, only present below branch axils on main stem. *Leaf scales* triangular, 1.0–3.2 × 1.0–1.5 mm, grey with dark blotches, becoming smaller distally, and finally disappearing. *Branches* 1–5, 117–134 mm long, arising in clusters from stem, curving upwards, very hairy. *Branchlets* absent. *Cladodes* (6–)8–10 in fascicle, up to 36 in terminal fascicles, clavate to linear, (1.5–)4.0–6.4 (–10) × 0.5 mm long, olive green, slightly curved, apex apiculate, 0.5 mm long, 6- or 7-angled, with simple white hairs (0.2 mm long) along angled ridges, hairs radiating out to side alternately. *Flowers* single, borne in cladode fascicle, no scent detected. *Pedicel* 0.5–2.0 mm long, articulated in top half, hairy, base surrounded by cluster of small membranous scales. *Tepals* 6, 3 larger 2.1–2.5 × 1.0–1.5 mm, 3 smaller 2–2.1 × 0.9–1.0 mm, white, median stripe brownish, with a ridge of hairs, apex acute, margin sometimes serrated. *Stamens* 6; filaments 2.6–3.5 mm long, fused length 1.5 mm, free length 1.1–2.0 mm; anthers orange. *Style* 1 mm long; stigma 3-fid, arms 0.1–0.2 mm long. *Ovary* trilobular, 1.0–1.5 × 1 mm. *Fruit* a berry, 5–7 mm diam., red when ripe, with persistent perianth. All measurements of cladodes, leaf scales, flowering and fruiting parts taken from pickled material. *Flowering time*: September to November. Figure 3.

Specimens examined

LIMPOPO.—2429 (Zebedelia): Ga Makopane, Zeekoegat Farm 421 KS, near Atok Platinum Mine, hill slope, 850 m, (–BD), 15 October 1997, N.H.G. Jacobsen 5540 (PRE); Zeekoegat Farm 421 KS, near Atok Platinum Mine, 850 m, (–BD), 10 November 1997, ex cultivation, N.H.G. Jacobsen 5717 (PRE); hills above Atok Mine, Monametsi R., Sekhukhuneland, (–BD), 29 November 2005, J.E. & S.M. Burrows 9307 (BNRH, PRE).

Distribution and habitat: this small, extremely hairy asparagus is currently known only from the hills near the Atok Platinum Mine at Monametse in Sekhukhuneland (Figure 2). The plants grow on rocky hillsides, amongst small rocks, in full sun, or occasionally in the scant shade of the surrounding vegetation, on medium- to coarse-grained titanite-bearing tonalite (granite), in vegetation type SVcb 28, Sekhukhune Mountain Bushveld (Mucina & Rutherford 2006). The plant is threatened and is therefore afforded VUD 1 & 2 conservation status (D. Raimondo pers. comm. 2006).

Diagnostic characters and affinities: although *Asparagus hirsutus* is compared with *A. capensis* L. var. *capensis* and *A. minutiflorus* (Kunth) Baker, the taxon differs significantly in the following details: *A. hirsutus* is an erect foxtail, with straight stems; the tubers are ellipsoid; the main stem is covered in white hairs; the spines are densely hairy; the leaf scales are glabrous with entire margins; the pedicel is hairy and is articulated in the top half; and the tepals have a ridge of hairs along the median stripe. *A. capensis* var. *capensis* is a much-branched shrub up to 1.5 m high; tubers absent; the main stem is glabrous; the spines are sparsely hairy, becoming glabrous; the branches end in a spine; the leaf scales are hairy with a lacerate margin; the flower is sessile; and the tepals are puberulous throughout. Although *A. minutiflorus* has tubers and a foxtail growth form, the branches typically arch or sprawl along the ground. It differs from *A. hirsutus* in that the cladodes are filiform; the hairs are glandular and golden brown; the spines have a few hairs at the base; the leaf scales have lacerate margins; and the pedicel is glabrous and is articulated in the lower half.

The known distribution of *A. hirsutus* is a distinguishing character: whereas *A. capensis* var. *capensis* only occurs in the Cape Province and southern Namibia, *A. minutiflorus* has a wider distribution, occurring in dry areas of Mpumalanga, Limpopo, Swaziland, KwaZulu-Natal and southern Mozambique.

TABLE 1.—Differences in morphology of *Asparagus elephantinus* and *A. densiflorus*

Character	<i>A. elephantinus</i>	<i>A. densiflorus</i>
Stem length	up to 3 m	up to 650 mm
Branch length	up to 0.6 m	up to 200 mm
Branchlets	up to 150 mm	absent
Spines	20 mm long, thick	1–7 mm long, thin
Tuber		
shape	broadly ellipsoid	ellipsoid
size	30–51 × 22–40 mm	13–45 × 6–22 mm
Pedicel articulation	in lower half	in middle
Berry	up to 14 mm diam.	up to 10 mm diam.

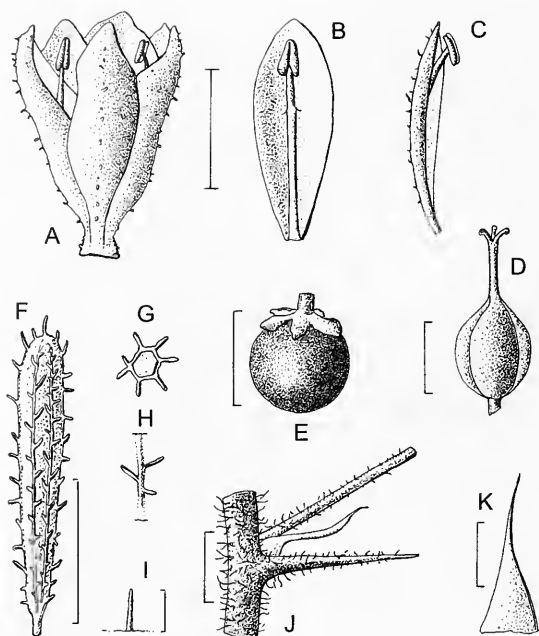


FIGURE 3.—*Asparagus hirsutus*, L.M.D. Riddles 511. A–D, floral details: A, flower; B, stamen and tepal, front view; C, stamen and tepal, side view; D, ovary. E, fruit; F, cladode; G, c/s cladode; H, I, simple hairs; J, spine and leaf scale; K, leaf scale. Scale bars: A–C, 1.6 mm; D, 1 mm; E, 6.6 mm; F, 2.2 mm; I, 0.2 mm; J, 4.4 mm; K, 1.6 mm. Artist: Sandra Burrows.

Etymology: *Asparagus hirsutus* is not easily confused with any other *Asparagus* species, as the extreme hairiness of the plant, (hence the specific epithet), the fox-tail growth form, and its limited distribution render it unmistakable.

***Asparagus sylvicola* S.M.Burrows, sp. nov., *A. setacei* similis sed ramulis late dispersis, cladodiis ramulisque ad angulum 90° caule patentibus, tuberibus fusiformibus differt.**

TYPE.—Mpumalanga, 2531 (Komatipoort): Bearded Man, Songimvelo Nature Reserve, Barberton Mtns, 1 400 m, (–CB), 16 April 2005, J.E. Burrows 8931 (PRE, holo.; BNRH, iso.).

Scandent to twining, evergreen shrublet up to 3 m high, glabrous throughout. *Rhizome* creeping; roots up to 3 mm thick, terete, with rootlets; mature plants develop spindle-like in-line tubers, 20–100 × 5–17 mm. *Stems* 2–4 mm thick, basally very finely papillate-ridged, dark olive green to purplish; leaf scales set on very small swellings. *Spines* absent throughout. *Leaf scales* triangular, 0.5–3.0 × 0.5–1.0 mm long, dark purple to reddish brown, pale on old stems, triangular, base with small (0.5 mm) soft protuberance, margin entire. *Branches* up to 400 × ± 1 mm, widely placed along stem, arising at right angles to stem, slightly zigzagging, terete, ridged. *Branchlets* 0.5 mm thick, up to 120 mm long, terete, widely spaced along branches, arising at right angles to branch. *Secondary branchlets* up to 25 mm long, same thickness as cladodes, arising at right angles to branchlets. *Cladodes* 1–9 per fascicle, filiform,

terete, falcate, (5)–9–20(–28) mm long, 0.5 mm to hair-like in width, glossy dark green. *Flowers* 1 or 2(–4), borne in terminal cladode fascicle, bud dark purple, no scent detected. *Pedice* 3 mm long, dark purple, articulated in top half, base surrounded by small membranous bracts. *Tepals* 6, 3 larger tepals 3.0–3.5 × 1.9–2.1 mm and 3 smaller tepals 2.5–3.0 × 1.0–1.5 mm, apex sometimes notched, underside streaked with purple. *Stamens* 6; filaments 2.75–3.25 mm long, fused at base; anthers pale lemon yellow. *Style* 1.8–2.5 × 0.5 mm, terete; stigma 3-fid, arms 0.7–1.0 mm long. *Ovary* trilocular, 0.9–1.1 × 1.5–2.0 mm. *Fruit* a berry, 6–10 mm diam. with persistent perianth and style, black when ripe. All measurements of cladodes, leaf scales, flowering and fruiting parts taken from pickled material. *Flowering time*: although seldom floriferous, the main flowering time is from November to January, with the occasional flower produced throughout the rest of the year. Figure 4.

Distribution and habitat: *Asparagus sylvicola* was first noted growing in forested areas in the Barberton Mountains in Mpumalanga and in the Lubombo Mountains in Swaziland (Figure 2). A number of specimens previously attributed to *A. setaceus* (Kunth) Oberm. are now included in this species, extending the distribution to include the forested areas of north-eastern South Africa, from Haenertsberg (Limpopo) to Siteki (Swaziland). The plant is widespread in these areas, although seldom common and, since much of the remaining habitat is protected, so therefore is this species.

Diagnostic characters and affinities: *Asparagus sylvicola* may be confused with *A. setaceus* (Kunth) Jessop but the most distinctive difference is that the branches of *A. sylvicola* radiate out at right angles and the cladodes arise in all directions, forming a compact, springy nonaligned tangle of cladodes, whereas *A. setaceus* has its branches and cladodes arranged in a horizontal plane. The cladodes of *A. sylvicola* are falcate, and in some specimens bow-shaped, whereas the cladodes of *A. setaceus* are straight to slightly curved. The tubers on mature plants of *A. sylvicola* resemble small long sweet-potatoes (spindle-like), and are in-line in the main roots, whereas the tubers of *A. setaceus* are ovoid to ellipsoid and are borne laterally.

Etymology: *Asparagus sylvicola* ('forest dweller') is so named as it favours forest, either Scarp Forest (FOz 5) or the lower regions of Northern Mistbelt Forest (FOz 4), (Mucina & Rutherford 2006).

Cultivation: *Asparagus sylvicola* has been cultivated as a container plant for several years, and makes a very attractive horticultural subject.

Specimens examined

LIMPOPO.—2329 (Pietersburg): Haenertsberg, (–DD), November 1913, R. Pott 4689 (PRE).

MPUMALANGA.—2430 (Pilgrim's Rest): Mariepskop, near Klaserie Drift, (–DB), 8 April 1969, P. Vorster 616 (PRE, PRU); Mt Sheba, 1 700 m, (–DC), 2 October 1986, Deall 2163 (PRE!). 2530 (Lydenburg): Ceylon Forest Reserve, 'Jantjesbos', 1 350 m, (–BA), 7 October 1986, Deall 2193 (PRE). 2531 (Komatipoort): Kaalrug road, Malelane Dist., 350 m, (–CB), 6 February 2003, J.E. & S.M. Burrows

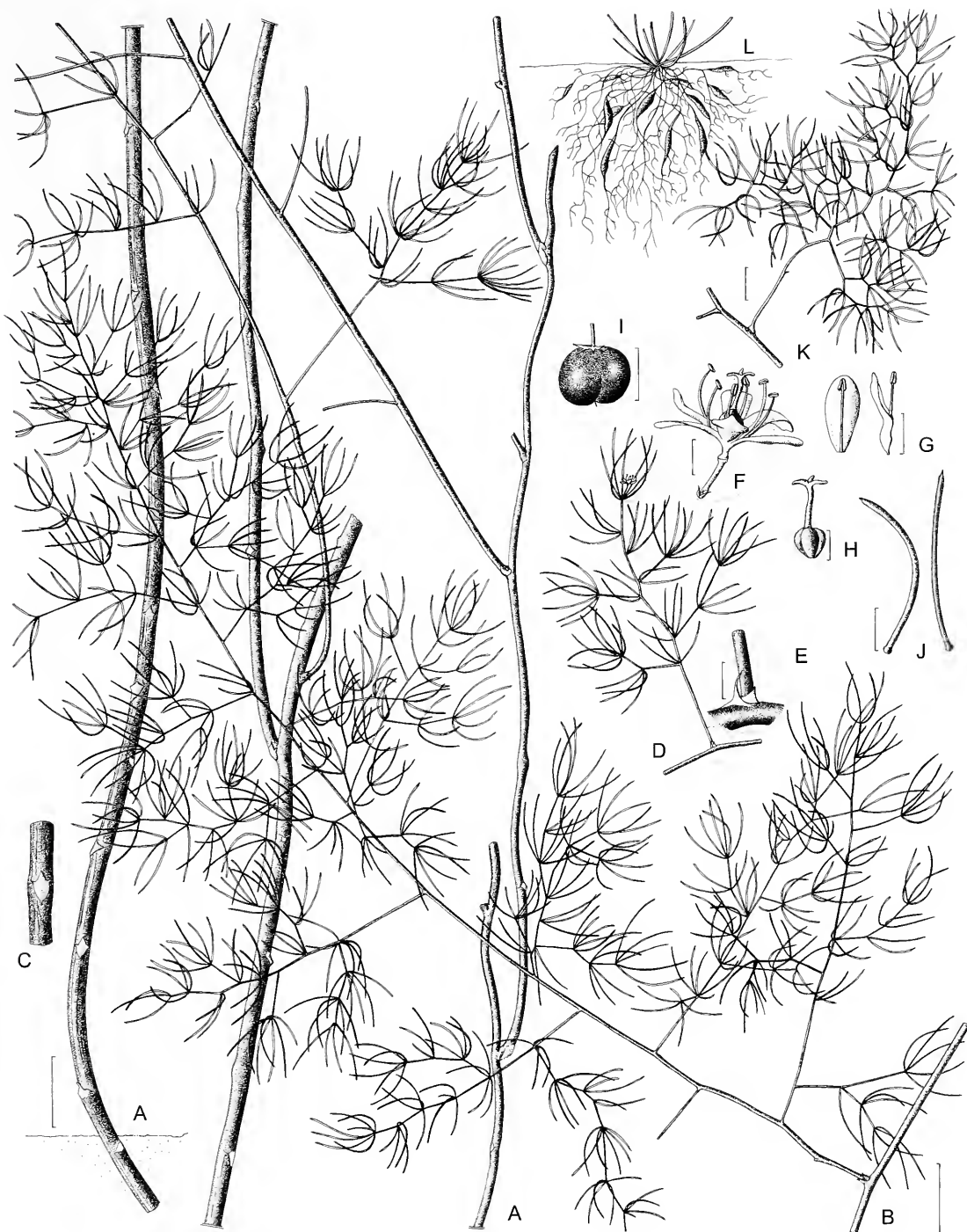


FIGURE 4.—*Asparagus sylvicola*, J.E. Burrows 8931. A–C, K, stem and branch; D, flowering branchlet; E, leaf scale. F–H, flower details: F, flower; G, front and side view of tepal and stamen; H, ovary. I, fruit; J, cladodes; L, rhizome habit. Scale bars: A–D, 11.8 mm; E, 5.3 mm; F, G, 1 mm; H, 1.8 mm; I, 3.5 mm; J, 2.9 mm; K, 5.9 mm. Artist: Sandra Burrows.

7975 (BNRH); Ida Doya Reserve, Barberton Mtns, (–CB), M.C. Lotter s.n. (BNRH); Barberton Mtns, Pedlar's Bush, 1 280 m, (–CC), 29 October 2006, J.E. & S. M. Burrows 9559 (BNRH, PRE); Barberton, Pedlar's Bush, 1 100–1 500 m, (–CC), January 1996, T.L. Morgenthal s.n. (PRE, PUC); Barberton, (–CC), June 1907, Thornecroft s.n. (Herb. Tvl. Mus. 4349 in PRE).

SWAZILAND.—2631 (Mbabane): Malagwane Hill, Mbabane, 3570' [1 088 m], (–AA), 22 June 1961, Ben Dlamini s.n. (PRE, SNHD); *ibid.*, 22 June 1961, B. Dlamini s.n. (PRE, SNHD); *ibid.*, 4 May 1961, B. Dlamini s.n., (PRE, SRGH). 2632 (Bela Vista): Mtibhlati River, Lubombo Mtns, Siteki area, 340 m, (–CA), 22 November 2002, J.E. & S.M. Burrows 7895 (BNRH).

Distribution of Asparagus acocksii Jessop, and *Asparagus lynetteae* (Oberm.) Fellingham & N.L.Mey.

The confusion in the identification between *Asparagus acocksii* and *A. lynetteae* in herbaria, due to the lack of material or information on the rooting system, has led both Jessop (1966) and Obermeyer & Immelman (1992) to accept that *A. acocksii* occurs disjunctly from the Eastern Cape to northern KwaZulu-Natal, Mpumalanga and Sekhukhuneland, Limpopo Province. When Obermeyer & Immelman (1992) described the new species *A. lynetteae* from Sekhukhuneland, they failed to realize that Jessop's '*A. acocksii*' (Jessop 1966) from Sekhukhuneland was conspecific with *A. lynetteae*.

In the type description of *Asparagus acocksii*, Jessop (1966) states that the stems are 'erect to scrambling', and that 'there are single records from both Zululand and the Transvaal'. Having now visited the type localities of both *A. acocksii* and *A. lynetteae*, the following is noted. *Asparagus acocksii* is a very small shrublet, up to 450 mm high. Where the stems are longer than usual (up to 1 m), they arch downwards but show no inclination to climb. The rhizome is compact and woody, the roots terete, up to 5 mm in diameter, with lateral, ovoid tubers, 26–37 × 19–23 mm. *A. acocksii* was previously considered to occur from the Eastern Cape to KwaZulu-Natal and the Transvaal (Mpumalanga and Limpopo).

Asparagus lynetteae is a lax, shrubby scrambler, with a tendency to climb up to 1.5 m. The rhizome is compact, with numerous thick, ribbed roots, ± 20 mm diameter and more than 1 m long, with terete side roots. Tubers are absent. Up to now *A. lynetteae* was considered to be a narrow Sekhukhuneland endemic, and possibly threatened.

Since most of the collections of *Asparagus lynetteae* have been made with either no roots or without reference to the roots, and since the vegetative parts closely resemble those of *A. acocksii*, these two taxa have been confused in herbaria and their true geographical distributions have been clouded. However, re-collections of the plants and the roots by the authors at the non-Cape '*A. acocksii*' sites have established that all these plants bear thickened, terete, tuberless roots and are therefore *A. lynetteae*, thus establishing that *A. acocksii* is restricted to the dry regions of the Eastern Cape, and that *A. lynetteae* is no longer endemic to the Sekhukhuneland area, but is sporadic in the bushveld areas of Mpumalanga, Swaziland, KwaZulu-Natal, and possibly in neighbouring southern Mozambique. Figure 5.

***Asparagus acocksii* Jessop** in *Bothalia* 9: 74, t. 7 (1966); *Protoasparagus acocksii* (Jessop) Oberm.: 243 (1983). Type: Cape, Cradock District, 12 miles NNE of Fish River Station, (–CB), *Acocks* 16296 (PRE, holo.!).

Additional specimens examined

EASTERN CAPE.—3125 (Steynsburg): 21.6 km from Fish River Station, opp. Grassridge Dam, 1 100 m, (–CB), 16 Feb. 2006, *J.E. & S.M. Burrows* 9376 (BNRH). 3126 (Queenstown): 5 km from Queenstown on Cathcart road, 1 150 m, (–DD), 1 February 2006, *J.E. & S.M. Burrows* 9452 (BNRH). 3223 (Rietbron): between Beaufort West and Aberdeen, (–BD), 23 April 1985, *M.B. Bayer* 4705 (PRE).

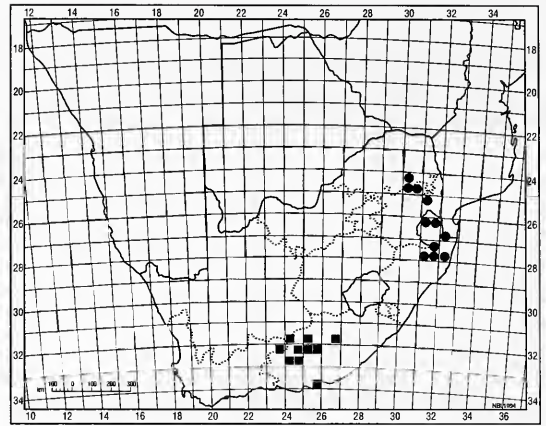


FIGURE 5.—Known distribution of *Asparagus acocksii*, ■, and *A. lynetteae*, ●.

3224 (Graaff-Reinet): Graaff-Reinet, (–BC), 7 May 1954, *Henrici* 4964, (PRE); Graaff-Reinet, Karoo Nature Reserve, Allardice R., eastern reserve on western slope along road from pump house, (–BC), 20 July 1981, *C. Reid* 1544 (PRE); Lusanne, E of Aberdeen, (–CA), 11 December 1983, *M.B. Bayer* 3740A (PRE); Krugerskraal near Graaff-Reinet, (–CD), November 1984, *W.R. Brand* s.n. (PRE). 3225 (Somerset East): S of Swaershoek Pass, on road from Cradock to Somerset East, 1 108 m, (–AD), 24 February 2004, *J.E. & S.M. Burrows* 8347 (BNRH, PRE); Cradock, 1 km S of Marlow, (–BA), 24 January 1985, *M.B. Bayer* 4318 (PRE); Mountain Zebra National Park, eastern region, (–BA), 5 September 1959, *P.J. Barnard* 513 (PRE). 3325 (Port Elizabeth): 'Aloes', (–DC), December 1912, *Drege* s.n. (PRE3164).

***Asparagus lynetteae* Oberm.** in Obermeyer & Immelman, *Flora of southern Africa* 5,3: 47 (1992). Type: near Burgersfort, in dense bushveld at Gethlane Lodge, *Mauve, Reid & Smook* 5408 (PRE, holo.!).

Additional specimens examined

LIMPOPO.—2430 (Pilgrim's Rest): on way to Penge, (–AC), 26 January 1972, *G.D. Wright* G36 (PRE); Moshira, Motse River, on road to Penge, 730 m, (–AC), 15 January 2002, *J.E. & S.M. Burrows* 8783 (BNRH, PRE); pass W of Penge Mine, on road to Chuniespoort, 1 250 m, (–AC), March 2005, *J.E. & S.M. Burrows* 8913 (BNRH, PRE); ibid. 6 March 2005, *J.E. & S.M. Burrows* 8917 (BNRH, PRE); ibid. 15 January 2005, *J.E. & S.M. Burrows* 8788 (BNRH, PRE); Burgersfort, 5 km NE of Alverton Village, 689 m, (–CA), 5 April 2005, *J.E. & S.M. Burrows* 8955 (BNRH); at Gethlane Lodge, Farm Fraaiuitzicht 843 KT, 860 m, (–CD), 20 November 1985, *Krynauw* 914 (LYD, PRE); 2 miles [3.2 km] N of Ohrigstad, (–DA), 22 November 1933, *R.G.N. Young* A616 (Tvl. Mus. Herb 32648 in PRE).

MPUMALANGA.—2430 (Pilgrim's Rest): 13.6 km on Steelpoort/Gethlane road near Steelpoort, 840 m, (–CC), 4 August 2002, *J.E. & S.M. Burrows* 7751 (BNRH, PRE). 2531 (Malelane): Magnesite Mine, between Kaapmuiden & Malelane, 630 m, (–CB), 17 April 2005, *J.E. & S.M. Burrows* 8951 (BNRH, PRE); ibid. 6 February 2003, *J.E. & S.M. Burrows* 7972 (BNRH, PRE).

SWAZILAND.—2631 (Mbabane): Mlawula Mountain Resort, near top entrance gate, 566 m, (–AA), 2 December 2006, *J.E. & S.M. Burrows* 9652 (BNRH); Swaziland lowveld near Mliba, (–BC), 14 January 1973, *D.N.H. Horter* 110 (PRE).

KWAZULU-NATAL.—2632 (Bela Vista): Ingwavuma District, Ndu-mu Game Reserve, 200' [61 m], (–CD), 10 February 1954, *C.J. Ward* 2038 (NPB Herb., PRE); Ingwavuma District, Ndu-mu Game Reserve, 130' [40 m], 15 November 1962, *C.J. Ward* 4522 (NU, PRE); Ndu-mu Game Reserve, Mahemane, 40 m, (–CD), 15 October 1990, *Thornhill* 283 (PRE). 2731 (Louwsberg): 12 km N of Magudu on tar road to Pongola, (–BC), 18 February 1982, *Reid* 491 (PRE); Ngotshe District,

Pongola Irrigation Scheme, 800' [244 m], (–CD), 16 October 1963, *C.J. Ward 4766* (PRE); 3 km along Candover road from Mahlangasi, off Pongola-Nongoma road, 345 m, (–DA), 9 June 2006, *J.E. & S.M. Burrows 9460* (BNRH).

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A new species of *Euclea* (Ebenaceae) from ultramafic soils in Sekhukhuneland, South Africa, with notes on its ecology

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Keywords: Ebenaceae, *Euclea* Murray, ecology, new species, Sekhukhuneland, South Africa, summer rainfall region, taxonomy

ABSTRACT

Euclea sekhukhuniensis Retief, Siebert & A.E. van Wyk, a new species with a restricted range in Sekhukhuneland, South Africa, is described, illustrated and compared with other members of the genus. It is a gregarious geoxyllic suffrutex forming large, much-branched colonies. The species is closely related to the small tree/shrub *E. linearis* Zeyh. ex Hiern from which it can be distinguished by its larger fruits, broader leaves and exclusively suffrutex growth form. Geographical range and habitat preference also differ between the two taxa. *E. sekhukhuniensis* is endemic to the Sekhukhuneland Centre of Plant Endemism, where it is confined to the calcareous, heavy-metal soils of the Steelpoort River Valley.

INTRODUCTION

Areas underlain by ultramafic rocks in Mpumalanga and Limpopo, and adjacent parts of Zimbabwe, contain a rich but still poorly studied flora. Examples of taxa newly described from these substrates include *Searsia pygmaea* (Anacardiaceae) from serpentinite near Barberton (Moffett 1999), *Rhoicissus sekhukhuniensis* (Vitaceae) from norite/pyroxenite near Steelpoort (Retief *et al.* 2001) and *Peristrophe serpenticola* from the Great Dyke (Balkwill & Campbell-Young 2001). Recent vegetation surveys of the ultramafic rocks of the Sekhukhuneland Centre of Plant Endemism (SCPE), a microregional centre of plant endemism and diversity (Van Wyk & Smith 2001), have revealed many undescribed plant taxa endemic to this phytogeographical region (Siebert *et al.* 2001). Future floristic surveys in this under-collected region are likely to reveal many new distribution records and possibly further new taxa. Other species known to be endemic to the SCPE include *Raphionacme villicorona* (Apocynaceae), *Asparagus sekukuniensis* (Asparagaceae), *Acacia ormocarpoides*, *A. sekhukhuniensis*, *Elephantorrhiza praetermissa* (Fabaceae), *Euphorbia barnardii*, *E. sekukuniensis* (Euphorbiaceae), *Gladiolus sekhukhuniensis* (Iridaceae), *Plectranthus porcatus*, *P. venteri* (Lamiaceae), *Hibiscus coddii* subsp. *barnardii* (Malvaceae), *Searsia batophylla*, *S. sekhukhuniensis* (Anacardiaceae), *Zantedeschia jucunda* and *Z. pentlandii* (Araceae).

The SCPE lies to the west of the northeastern section of the Great Escarpment of South Africa and is characterized by a heterogeneous geology, topography and climate (Van Wyk & Smith 2001). The core area of the Centre straddles the border of Mpumalanga and Limpopo, around the towns of Burgersfort, Mecklenburg, Roossenekal, Schoonoord and Steelpoort. The SCPE is best demarcated in geological terms as the

large, far-eastern outcrop of ultramafic rocks belonging to the Rustenburg Layered Suite of the eastern Bushveld Complex. These rocks are mainly norite, pyroxenite, anorthosite and ferrogabbro, with localized intrusions of magnetite and chromitite (Viljoen & Schürman 1998). Topographically the SCPE is a mountainous area bordered by the high ground of the Drakensberg Escarpment in the north and east, the Highveld Escarpment to the south and the Springbok Flats to the west. It lies adjacent to and west of the Wolkberg (Van Wyk & Smith 2001) and Lydenburg (Schmidt *et al.* 2002) Centres of Plant Endemism, both part of the northeastern Drakensberg Escarpment.

Previously a *Euclea* taxon with a suffrutex habit and narrow elliptical leaves from Sekhukhuneland was tentatively considered a hybrid between *E. linearis* Zeyh. ex Hiern and *E. crispa* (Thunb.) Gürke subsp. *crispa* (De Winter 1963)—a suspicion based on the overlapping distribution ranges of these two species in Sekhukhuneland. However, subsequent detailed field work and comparative morphological studies have shown the putative hybrid to be a distinct new species, closely related to *E. linearis* and endemic to the ultramafic soils of the SCPE. The new species is here described as *Euclea sekhukhuniensis* Retief, Siebert & A.E. van Wyk. This is the second *Euclea* species, after *E. dewinteri* Retief (Retief 1986), an endemic of the Wolkberg Centre of Plant Endemism, that is strictly confined to the larger northeastern Drakensberg Escarpment.

The genus *Euclea* comprises ± 20 species, confined to Africa, Arabia, Socotra and the Comoro Islands, with its centre of diversity in southern Africa (Dyer 1975; Bredenkamp 2000). In addition to *E. sekhukhuniensis*, seven species and infraspecific taxa occur in the SCPE, namely *E. crispa* subsp. *crispa*, *E. divinorum* Hiern, *E. linearis*, *E. natalensis* A.DC. subsp. *angustifolia* F.White, *E. daphnoides* Hiern, *E. schimperi* A.DC. and *E. undulata* Thunb. (Table 1). However, the list is provisional, for the region is still poorly sampled. All these taxa are evergreen shrubs or trees, except *E. sekhukhuniensis*, which is an evergreen geoxyllic suffrutex. A form of *E. crispa* (White 1977) along the northeastern Drakensberg Escarpment (but not entering the SCPE) exhibits the same growth form as *E. sekhukhuniensis*.

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MATERIALS AND METHODS

Euclea specimens housed in the National Herbarium (PRE), Pretoria, and H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria (acronyms as in Holmgren *et al.* 1990) were examined to gather data on morphology, phenology and distribution.

Ecological data are based on extensive field observations of *Euclea linearis* and *E. sekhukhuniensis* in the SCPE (Siebert *et al.* 2002a, b). Specimens were sampled from the region during all seasons, environmental factors were noted and plant communities identified. The specimens Siebert 935, 937 and Van Wyk & Siebert 13060 were identified as typical *E. linearis* for comparing ecological traits with *E. sekhukhuniensis*. Plant material and soil samples were taken at ten sites, five each dominated by either *E. linearis* or *E. sekhukhuniensis*. Voucher specimens were taken from these sites; Siebert 937 represents *E. linearis* and Siebert 938 represents *E. sekhukhuniensis* (specimens kept at PRU). Soil analysis was done with X-Ray Fluorescence (XRF) Spectrometry, Department of Geology, University of Pretoria and plant analysis with Atomic Absorption Spectrophotometry (AAS) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) at the Department of Soil, Climate and Water in Pretoria.

TAXONOMY

***Euclea sekhukhuniensis* Retief, Siebert & A.E.van Wyk, sp. nov., *E. lineari* Zeyh. ex Hiern similis sed habitu (suffrutex, non frutex vel arbor parva), forma foliorum elliptica recta, non anguste elliptica nec lineari nec falcata, fructu globoso maiore (± 9 mm, non ± 5.5 mm diametro) differt.**

TYPE.—Mpumalanga, 2430 (Pilgrim’s Rest): 10 km NW of Maartenshoop, (–CC), Codd 8796 (PRE, holo.; K, iso.). Figure 1.

Euclea linearis Zeyh. ex Hiern *sensu* De Winter: 94 (1963) quoad Codd 8796.

Woody suffrutex, 0.3–1.5 m high, forming large colonies of much-branched clones ± 5 m diam. Plants evergreen, dioecious. Branches ascending, slender and glabrous, except for a rust-brown granular exudate on

TABLE 1.—Distribution of seven species of *Euclea* according to quarter-degree grid squares of SCPE

<i>Euclea</i> species/infraspecific taxa	2429BC	2429BD	2429DB	2429DD	2430AC	2430CB	2430CC	2430CD	2529BB	2530AA
<i>E. crisa</i> subsp. <i>crisa</i>
<i>E. divinatorum</i>
<i>E. linearis</i>
<i>E. natalensis</i> subsp. <i>angustifolia</i>
<i>E. schimperi</i> var. <i>daphnoides</i>
<i>E. schimperi</i> var. <i>schimperi</i>
<i>E. sekhukhuniensis</i>
<i>E. undulata</i>
Total	1	6	3	3	6	7	5	6	5	2



FIGURE 1.—*Euclea sekhukhuniensis*, Codd 8796, holo. (PRE).

young growth; bark grey on older stems. Leaves simple, subopposite, subsessile; blade oblanceolate-elliptic, straight, 25–75(–90) \times 4–8(–10) mm, glabrous, leathery and smooth, except for a rust-brown granular exudate on younger leaves, usually yellowish green above and pale green below; base tapering into a very short petiole (1 mm), apex acute to rounded, margin entire, main vein and principal lateral veins prominent above and below. Inflorescences axillary, few-flowered, clusters or short spikes. Flowers regular. Male flowers: calyx 4-lobed, ± 3 mm long; corolla campanulate, deeply 4-lobed, ± 5 mm long, pale cream-coloured to pinkish white, appressed hairy on back; stamens 8, narrowly ovate, ± 3 mm long, anther thecae pubescent on outer surface. Female flowers: calyx not accrescent, persistent in fruit, 4-lobed, ± 2 mm long; corolla 4-lobed, ± 4 mm long, green, lobes appressed hairy on back; ovary hairy, borne on a fimbriate, fleshy disc; styles 2. Fruit an indehiscent, globose berry, $\pm 9 \times 10 \times 8$ mm, densely appressed hairy; young fruits green, ripening through brownish red to purplish black. Flowering time: October to January. Fruiting time: November to February. Figure 2.

Diagnostic characters: members of *Euclea* can be divided into two groups (De Winter 1963): 1, species with the corolla shallowly lobed at the apex; and 2, species with the corolla cleft at least halfway down or more. All the *Euclea* taxa occurring in the SCPE belong to the latter group. *E. sekhukhuniensis* and *E. linearis* are dis-

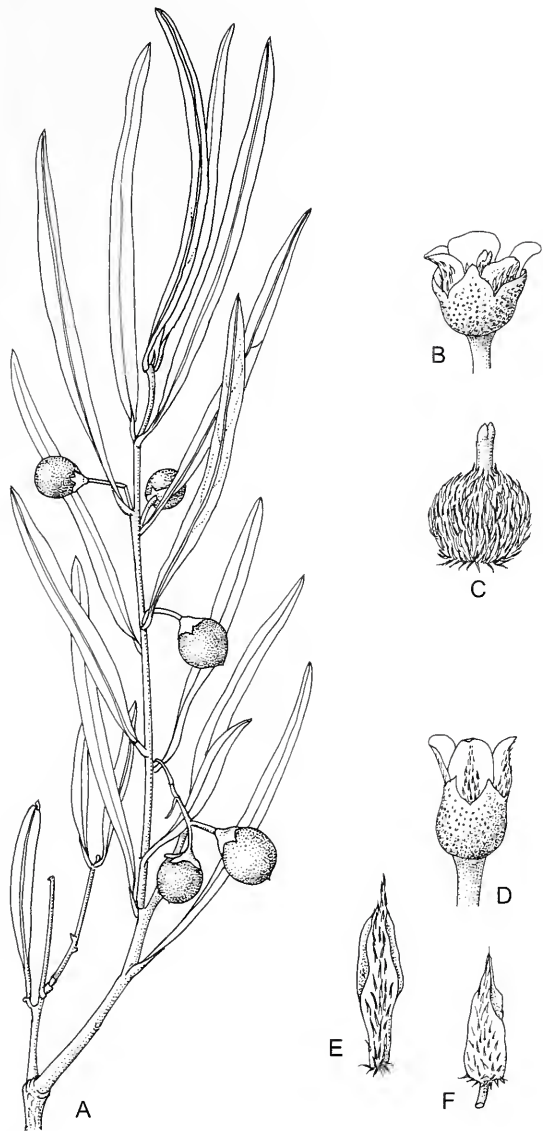


FIGURE 2.—*Euclea sekhukhuniensis*, Plant Specialist Group 4 (PRE). A, fruiting branch, $\times 0.75$; B, female flower, $\times 3.8$; C, gynoecium, $\times 7.5$; D, male flower, $\times 3.8$; E, stamen of outer row, $\times 7.5$; F, stamen of inner row, $\times 7.5$. Artist: G. Condy.

tinguished from the others by their narrowly oblanceolate-elliptic to linear or linear-falcate leaves and young leaves and twigs that are covered with a granular, rust-brown exudate. *E. sekhukhuniensis* is most closely related to *E. linearis*; however, *E. sekhukhuniensis* is a gregarious, evergreen geoxylic suffrutex (White 1977), whereas *E. linearis* is a shrub or tree up to 5 m high. Leaves of *E. sekhukhuniensis* are straight, broader and longer than the sickle-shaped leaves of *E. linearis* and its fruits are larger than those of *E. linearis* (Table 2).

Conservation status: *Euclea sekhukhuniensis* has a restricted geographical range within which it is locally fairly common (Figure 3). However, some of its habitat is under immediate threat of rapid urbanization as a result of increased mining activities in the greater

Steelpoort River Valley and the construction of the De Hoop Dam on the Steelpoort River. *E. sekhukhuniensis* is not formally protected in any conservation area. Populations of this species should therefore be closely monitored and a Red Data List assessment of this species prioritized. Its conservation value is considered relatively high, as it could possibly be used in the rehabilitation of mine dumps due to its internal mechanism of excluding heavy metals.

Ecology and speciation: both *Euclea sekhukhuniensis* and *E. linearis* occur on vegetation anomalies—sparsely vegetated soils that are mineralized (Table 3). This phenomenon is well reported for populations of *E. linearis* in wooded grassland on the serpentinites of the Great Dyke in Zimbabwe (Wild 1965). A distant outlier of what has been identified as *E. linearis* is also found on grassy ridges in fynbos in a limited area in the Calvinia and Vanrhynsdorp region of the Western Cape, where it grows on nutrient-poor soils derived from sandstone of the Table Mountain Group (White 1983). However, the identity of these plants requires verification. In the mountainous regions of the northern provinces of South Africa, *E. linearis* grows on rocky outcrops and in dry woodlands on slopes and in valleys of serpentinite (Barberton Supergroup) in the Barberton region, acidic sandstone (Waterberg Group) of the Waterberg of Limpopo, and quartzites (Black Reef Formation) along the northeastern Drakensberg Escarpment (White 1983). Thus, it appears that *E. linearis* tends to colonize habitats with harsh soil conditions in mountainous regions (acidic, nutrient poor and/or rich in heavy metals).

Euclea sekhukhuniensis appears to be an example of incipient sympatric speciation due to ecological interactions in a new habitat in which restricted gene flow has evolved through selective reproduction between individuals of *E. linearis* that are adapted to a specific ultramafic substrate. This speculation is supported by the work of Alados *et al.* (1999), which demonstrates that asymmetry and within-plant variance were higher between specimens of the same species in the contact zone between ultramafic and normal soils. In the SCPE, habitat preference has resulted in the two *Euclea* species

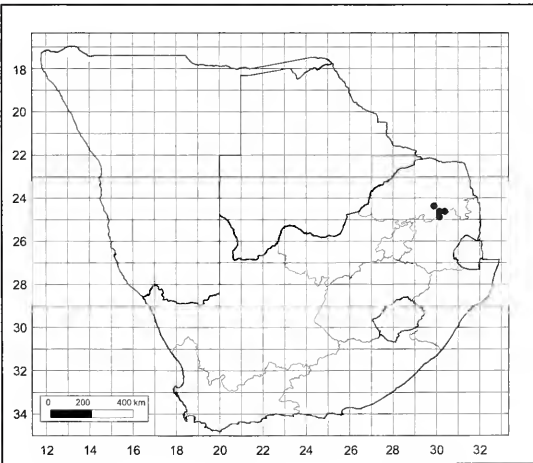


FIGURE 3.—Known distribution of *Euclea sekhukhuniensis*.

TABLE 2.—Leaf and fruit measurements of 15 *Euclea sekhukhuniensis* specimens and only results of 30 randomly selected specimens of *E. linearis* from Mpumalanga and Limpopo (all in PRE)

No.	Collector no., herbarium	Grid	Locality	Mature leaf (mm)				Mature fruit (mm)			
				Length		Width		Length		Width	
				Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.	Herman 793 (PRE)	2430CB	Burgersfort	55	27	6	4	11	9	9	8
2.	Van Wyk, Siebert & Retief 13204 (PRU)	2430CC	Frischgewaagd	76	19	6	4	-	-	-	-
3.	Siebert 411 (PRU)	2430CC	Frischgewaagd	81	22	7	4	10	9	9	8
4.	Barnard & Mogg 1031 (PRE)	2429BD	Leolo Mountains	89	31	9	5	-	-	-	-
5.	Wright G14 (PRE)	2430CA	Maandagshoek	80	26	8	5	11	9	10	9
6.	Kritzinger 138(PRE)	2430CA	Maandagshoek	80	22	10	6	10	-	10	-
7.	Codd 8796 (PRE)	2430CC	Maartenshoop	81	39	10	5	8	7	7	6
8.	Siebert 938 (PRU)	2430CC	Olifantspoortjie	85	19	6	3	-	-	-	-
9.	Van Wyk 13299 (PRU)	2430CC	Steelpoort	62	21	7	5	10	9	9	8
10.	Van Wyk 13035 (PRU)	2430CC	Thornecliffie	75	23	7	3	9	8	8	7
11.	Van Wyk 13036 (PRU)	2430CC	Thornecliffie	82	20	7	4	12	9	10	9
12.	Van Wyk & Siebert 13312 (PRU)	2430CC	Thornecliffie	60	19	7	2	-	-	-	-
13.	Van Wyk & Siebert 13313 (PRU)	2430CC	Thornecliffie	76	23	9	4	10	8	9	7
14.	Plant Specialist Group 4 (PRE)	2430CC	Thornecliffie	86	22	7	4	11	8	8	7
15.	Siebert 934 (PRU)	2430CC	Tweefontein	68	18	12	5	-	-	-	-
<i>Euclea sekhukhuniensis</i> mean measurement (15 specimens)				76	23	8	4	10	8	9	8
<i>Euclea linearis</i> mean measurement (30 specimens)				52	28	2.5	1.8	5.9	-	5.4	-

now growing in specific, but different habitats in association with specific plant species (Tables 3, 4). According to Dieckmann & Doebeli (1999), theoretical evidence suggests a prominent role for ecologically driven speciation in sympatry. Hence, the present study supports the

opinion that the ecological species concept is an essential part of the biological species concept (Grant 1992).

TABLE 3.—Environmental, structural and floristic characteristics unique to plant communities dominated by either *Euclea sekhukhuniensis* or *E. linearis* in Steelpoort River Valley

Characteristics	<i>E. sekhukhuniensis</i>	<i>E. linearis</i>
Slope (°)	4 (0–9)	3 (1–5)
Aspect	S, N	S, W
Rock cover (%)	45 (25–70)	40 (10–80)
Rock size (mm)	465 (100–1 500)	225 (50–500)
Soil type	Glenrosa, Valsrivier	Bonheim, Steendal, Valsrivier
Geology	pyroxenite, norite, magnetite	alluvium, pyroxenite, gabbro
Chemical composition	calcareous	brackish (sodic)
Topographical position	scarp, midslope, footslope	footslope, valley
Vegetation type	short, rocky, mountain bushveld	short, alluvial, mountain bushveld
Tree cover (%)	3	4
Shrub cover (%)	8	7
Forb cover (%)	11	11
Grass cover (%)	13	17
Total vegetation cover (%)	35	39
Mean tree height (m)	3	3
Mean shrub height (m)	1.7	1.8
Mean forb height (m)	0.6	0.6
Mean grass height (m)	1.25	1
Total no. species	105	96
Mean no. species/site	44	42
SCPE endemics	14	14
SCPE near-endemics	9	10
Red Data List taxa	4	4

Generally, ecologically driven speciation is the result of habitat-specific preferences. This has been investigated and confirmed for an endemic species of *Impatiens* and its widespread congener (Chung & Kang 1996), as well as for two endemic species of *Dicerandra* of the same region (Menges *et al.* 1999). In the case of *Euclea sekhukhuniensis*, an open niche with an anomalous Ca-rich substrate (14.68% = 146 800 ppm) in an otherwise typical environment of brackish soils rich in Mg (19.97% = 199 700 ppm), probably favoured speciation (Figure 4A). Similar trends have been perceived between especially limestone (Ca-rich) and sandstone, once again for an endemic and its widespread congener (Walck *et al.* 1999), as well as two endemics of the same region (Mustart *et al.* 1994). Like limestone, the soils inhabited by *E. sekhukhuniensis* are Ca-rich (1.95Ca:1Mg), more than double that of the soil substrate of *E. linearis* (Figure 4A). Furthermore, soils in which *E. linearis* grows have higher concentrations of total Cr and Ni (typical elements of serpentinite) (Figure 4B), with high Fe, Si and Mg levels (1Mg:0.34Ca) (Figure 4A), and it accumulates relatively high concentrations of Al and Fe in its roots (Figure 5A). *E. sekhukhuniensis* accumulates lower levels of Fe in its roots, but with higher concentrations of Cr and Ni than *E. linearis*, although these levels are very low and not regarded as hyperaccumulation (Figure 5A). Overall, it seems that *E. sekhukhuniensis* is the better excluder of heavy metals, when considering the high concentrations of metals in the associated soil.

It is suggested that *Euclea sekhukhuniensis* was an ecotype of and has developed from *E. linearis* as a result of the genetic properties of the latter to adapt to and colonize ultramafic soils such as those derived from serpentinite (Wild 1974). It is hypothesized that *E. sekhukhuniensis* is a 'soil-adapted' neo-endemic which speciated

TABLE 4.—Prominent taxa recorded for communities dominated by either *Euclea sekhukhuniensis* or *E. linearis* in Steelpoort River Valley (Siebert *et al.* 2002b)

Life forms	Species dominant in:		
	<i>Euclea sekhukhuniensis</i> dominated community	<i>Euclea linearis</i> dominated community	Both communities
Grass layer	<i>Heteropogon contortus</i>	<i>Andropogon chinensis</i>	<i>Brachiaria serrata</i>
	<i>Tristachya leucothrix</i>	<i>Fingerhuthia africana</i>	<i>Diheteropogon amplexens</i>
	<i>Setaria sphacelata</i>	<i>Loudetia simplex</i>	<i>Themeda triandra</i>
Forb layer	<i>Rhynchosia spectabilis</i>	<i>Dicoma gerrardii</i>	<i>Berkheya insignis</i>
	<i>Orthosiphon fruticosus</i>	<i>Petalidium oblongifolium</i>	<i>Gnidia caffra</i>
	<i>Jamesbrittenia macrantha</i>	<i>Rhynchosia komatiensis</i>	<i>Phyllanthus glaucophyllus</i>
Shrub layer	<i>Elephantorrhiza praetermissa</i>	<i>Grewia vernicosa</i>	<i>Brachylaena ilicifolia</i>
	<i>Diospyros lycioides</i> subsp. <i>nitens</i>	<i>Searsia keetii</i>	<i>Tinnea rhodesiana</i>
	<i>Hippobromus pauciflorus</i>	<i>Searsia wilmsii</i>	<i>Vitex obovata</i> subsp. <i>wilmsii</i>
Tree layer	<i>Catha edulis</i>	<i>Bolusanthus speciosus</i>	<i>Acacia caffra</i>
	<i>Cussonia transvaalensis</i>	<i>Combretum hereroense</i>	<i>Euclea crispa</i> subsp. <i>crispa</i>
	<i>Faurea saligna</i>	<i>Protea caffra</i>	<i>Lydenburgia cassinoides</i>

recently, after the Pleistocene (Reeves *et al.* 1983), and has not yet had the time or routes to migrate out of the Steelpoort River Valley. However, it is doubtful whether this will ever happen, as the species probably prefers the open niches of ultramafic soils where it has a physiological mechanism associated with high plant levels of Ca to tolerate heavy metals (Figure 5B).

Specific epithet and common names: the specific epithet refers to the geographical area where the species is endemic. Sekhukhuneland is traditionally inhabited by the Pedi (Mönnig 1967) and is currently under the reign of K.K. Sekhukhune (Paton 1998). Common names for the taxon include *moshigwane* (Northern-Sotho), Steelpoort guarri (English) and *Steelpoortghwarrie* (Afrikaans).

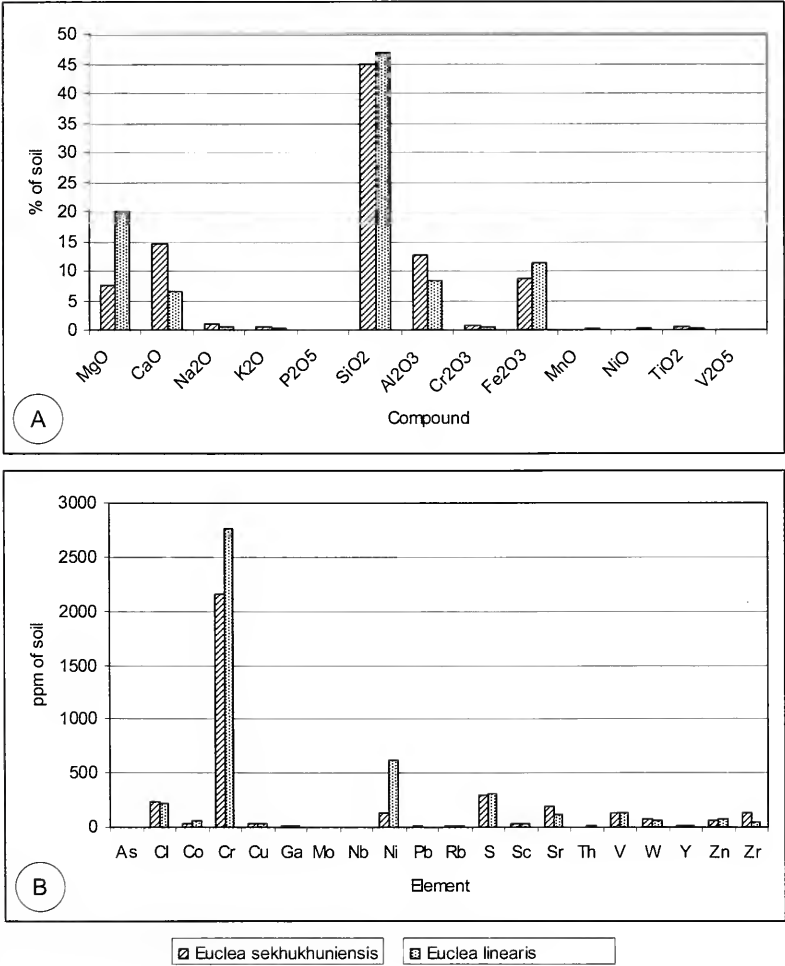


FIGURE 4.—Chemical analyses of five soil samples collected from root zone (300 mm deep) for each of *Euclea sekhukhuniensis* and *E. linearis*.

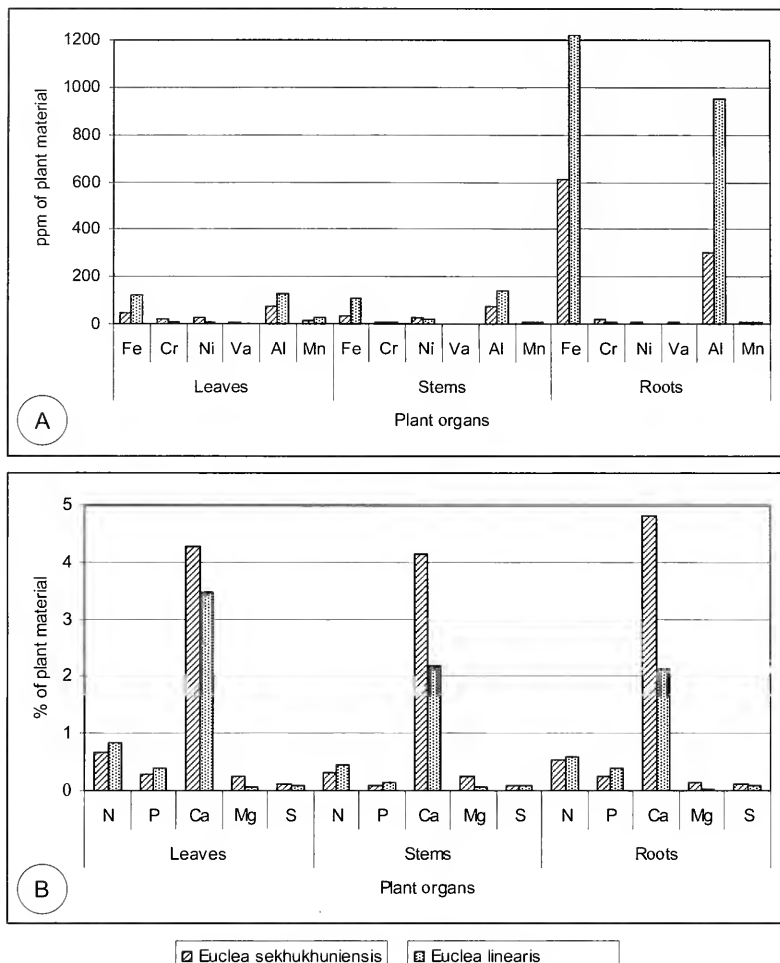


FIGURE 5.—Chemical analyses of plant material from five individuals each of *Euclea sekhukhuniensis* and *E. linearis* (young and old growth).

SPECIMENS EXAMINED

LIMPOPO.—2429 (Zebediela): Het Fort on Leolo Mountains, (–BD), *Barnard & Mogg 1031* (PRE). 2430 (Pilgrim's Rest): Maandagshoek, (–CA), *Kritzinger 138* (PRU), *Wright G14* (PRE).

MPUMALANGA.—2430 (Pilgrim's Rest): Burgersfort, (–CB), *Herman 793* (PRE); Maartenshoop, (–CC), *Codd 8796* (PRE); Frischgewaagd, (–CC), *Siebert 411*, *Van Wyk, Siebert & Retief 13204* (PRU); Thomecliff Chrome Mine, (–CC), *Plant Specialist Group 4* (PRE), *Siebert 934*, *Van Wyk 13035*, *13036*, *Van Wyk & Siebert 13312*, *13313* (PRU); Olifantspoortjie, (–CC), *Siebert 938* (PRU); Steelpoort, (–CC), *Van Wyk 13299* (PRU).

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The genus *Solanum* (Solanaceae) in southern Africa: subgenus *Leptostemonum*, section *Giganteiformia*

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Keywords: chemistry, ethnobotany, *Giganteiformia* (Bitter) Child, *Leptostemonum* (Dunal) Bitter, morphology, Solanaceae, *Solanum* L., southern Africa, taxonomy

ABSTRACT

In the genus *Solanum* L. (Solanaceae), subgenus *Leptostemonum* (Dunal) Bitter, section *Giganteiformia* (Bitter) Child has four representatives in the *Flora of southern Africa* region (South Africa, Namibia, Botswana, Swaziland, Lesotho), namely *S. giganteum* Jacq., *S. goetzei* Dammer, *S. tettense* Klotzsch var. *renschii* (Vatke) A.E.Gonçalves and *S. tettense* Klotzsch var. *tettense*. Descriptions, discussions, distribution maps and keys are presented, as well as an illustration of *S. goetzei*.

INTRODUCTION

In the genus *Solanum* L., the prickly subgenus *Leptostemonum* (Dunal) Bitter is represented by eight sections in southern Africa. Three sections (*Giganteiformia*, *Melongena*, *Oliganthes*) contain only indigenous taxa, and the remaining five sections (*Acanthophora*, *Androceras*, *Cryptocarpum*, *Leprophora*, *Torva*) have only introduced species. Section *Giganteiformia* (Bitter) Child is represented by four taxa in southern Africa; all are indigenous. *S. giganteum* Jacq. occurs from tropical Africa (also India and Sri Lanka) to the Western Cape, *S. goetzei* Dammer grows from Kenya to northern KwaZulu-Natal, while *S. tettense* is found from tropical Africa to Namibia, Botswana and the northern provinces of South Africa. Detailed descriptions and discussions are given for both the section and all four taxa, together with keys and distribution maps. *S. goetzei* is illustrated for the first time. Information on distribution, ecology, phenology and uses came from specimens in NH and PRE, unless otherwise stated.

DESCRIPTIONS AND DISCUSSIONS

Section *Giganteiformia* (Bitter) Child in Feddes Repertorium 109, 5 & 6: 415, 416 (1998). Lectotype species: *S. giganteum* Jacq. (Child 1998).

Series *Giganteiformia* Bitter: 255 (1921).

Description (based on Child 1998)

Medium-sized shrubs to small trees 2–6 m high, white-pubescent to tomentose-floccose with sessile to shortly stipitate stellate hairs (also some simple hairs), stellate hairs transparent and hyaline, often small, sometimes sparse. *Prickles* short, 2–6 mm long, \pm absent to many rosoid on stems, smaller on midribs, broad-based, recurved, laterally compressed, often sparse, sometimes absent or replaced with bristles. *Sympodial units* plurifoliate with inflorescence remaining erect for some time, especially on early order shoot generations (then branching dichasial); leaves and extended inflorescences often

aggregated terminally. *Leaves* broadly ovate to obovate, oblanceolate or ovate-lanceolate, petiolate (10–40 mm long), usually unarmed, entire to subrepand, rarely lobed, tip acute to acuminate or obtuse, basally acute or rounded, to at least 250 mm long on vigorous vegetative shoots, herbaceous, glabrescent above, white or canescently pubescent to tomentose below. *Inflorescence* cymose (in southern Africa) with few to many (20–80) dense, small, all bisexual flowers; peduncle 20–40 mm long, terminal and suberect until finally pushed laterally by continued shoot growth, sometimes armed with small deltoid/rosoid prickles; pedicels 15–18 mm long, nutant at anthesis, \pm erect in fruit. *Calyx* campanulate, lobes broadly ovate or deltoid. *Corolla* stellate, mostly less than 20 mm diam., mostly blue/purple, usually deeply divided, 4-, 5- or 6-lobed, lobes narrowly triangular or linear-lanceolate. *Stamens*: filaments free; anthers equal, subleptostemonoid, lanceolate, \pm attenuate. *Ovary* crowned with shortly stipitate floor glands or few stellate hairs; style glabrous. *Fruits* globose, held \pm erect, 6–12 mm diam., juicy, bitter, shiny, red to purplish when ripe. *Seeds* reticulate, 2.0–2.5 mm long, pale yellow. *Chromosome number*: $n = 12$ for *S. giganteum* (Bukonya-Ziraba 1996).

Distribution and ecology

Section *Giganteiformia* consists of \pm nine species in Africa, India and Sri Lanka. All these species are indigenous to Africa; only one species, *S. giganteum*, also occurs in India and Sri Lanka. Members of this section are centred in tropical East Africa from Ethiopia to Tanzania, but outlying species are found in tropical West Africa and temperate South Africa. They grow in grassland, savanna, forests and forest clearings and edges.

Taxonomy and relationships

In the subgenus *Leptostemonum* the plants are generally prickly at least when young; hairs, at least some of them, are truly stellate; inflorescences are extra-axillary; anthers are tapering, opening by terminal pores.

Bitter (1921) placed his series *Giganteiformia*, containing Afro-Asian species, with the neotropical species in section *Torva* Nees. Later authors realized that section *Torva* should not include these Afro-Asian plants.

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Whalen (1984) separated the *Giganteum* group. He observed that this group of African species is unusual in containing some species with plurifoliate and others with difoliate sympodia. The difoliate species tend to have smaller inflorescences and sometimes tetramerous flowers. However, many other distinctive characters unify the group, among them the entire, often markedly discolorous leaves with glabrate upper surfaces and closely spaced, upwardly arching lateral veins; the small broad-based prickles (often sparse); the inflorescence branches with closely spaced small, pendent flowers; the tendency to floral tetramery; and the small, juicy, erect red berries. Jaeger & Hepper (1986) kept them together in section *Torva* for convenience, but emphasized the differences between the neotropical, mainly Central American, species of section *Torva* (lobate leaves, bifoliate geminate sympodial units, white flowers and firmer, larger, green to yellow fruits) and the African species of that section. Thus, they concluded, *Solanum torvum* Sw. and *S. giganteum* Jacq. should not be in the same section.

Child (1998) noted that the appearance of his section *Giganteiformia* closely resembles that of species of section *Brevantherum* (of the subgenus *Brevantherum*) in branching pattern, in the attitude of the flowering and fruiting inflorescence and in leaf form. However, Child (1979) also noted that most species in section *Giganteiformia* are prickly, unlike section *Brevantherum*, but on the other hand, some species have a thick stellate indumentum like species of section *Brevantherum*. (Section *Brevantherum* has pleiochasial, multilateral corymbose to subumbellate cymes with a long common axis or peduncle but with reduced rachides. The inflorescence remains erect and shoot continuation is delayed until well after anthesis.) Bitter (1921) noticed that the pseudostipules leaves in the axils of cauline leaves in *Solanum giganteum* are similar to those of *S. mauritanum* and some other species of section *Brevantherum*.

Species of section *Giganteiformia* may therefore be regarded as parallel to the section *Brevantherum*, at least in respect of branching pattern and habit. According to Child (1998), plurifoliate sympodial units with ditrichasial branching, lanceolate or ovate unlobed leaves and pleiochasial inflorescences may be regarded as plesiomorphic characters within the genus *Solanum*.

Levin *et al.* (2006) concluded that most of the Old World species of subgenus *Leptostemonum* belong to a single species-rich clade. Their investigations of *Solanum kwebense* (from tropical and southern Africa) and *S. schimperianum* (from tropical Africa) suggest that within their large Old World clade, the *S. giganteum* group appears monophyletic.

Key to species of section *Giganteiformia* in southern Africa (based on Gonçalves 2005)

- 1a Leaves ± glabrous below at maturity; prickles absent; inflorescence a branched cyme; seeds 3–5 × 2.5–4.0 mm ... *S. goetzei*
- 1b Leaves markedly hairy below at maturity; prickles mostly present; inflorescence an unbranched or paniculiform cyme; seeds 2.5–3.8 × 2–3 mm:
 - 2a Leaves white floccose-tomentose below; anthers 2–4 mm long *S. giganteum*
 - 2b Leaves grey- or yellow-tomentose below; anthers 4–7 mm long *S. tettense*

1. *Solanum giganteum* Jacq., Collectanea austriaca ad botanicum 4: 125 (1791); Jacq.: 11, t. 328 (1793); Dunal: 258 (1852); Wright: 94 (1904); Wright: 229 (1906); Bitter: 256 (1921); Compton: 516 (1966); Palmer & Pitman: 1984 (1973); Symon: 117, t. 37 (1981); Whalen: 215, fig. 10 (1984); Beentje: 580 (1994); Van Wyk & Van Wyk: 118 (1997); Gonçalves: 88 (2005). Type: cultivated in Hortus Vindobonensis, Vienna, originally from the Cape, South Africa (Gonçalves 2005).

S. niveum Vahl ex Thunb.: 36 (1794). Type: from Cape of Good Hope, South Africa (Gonçalves 2005).

S. farinosum Wall. ex Roxb.: 255 (1824). Type: from India (Wright 1904).

Description (based on Gonçalves 2005)

Short-lived, soft-wooded, much-branched undershrub, shrub or sometimes a small tree, up to 6 m high; sympodia plurifoliate. *Hairs* stellate, white, very fine, floccose, ± sessile, regular, with many short rays. *Prickles* stout, straight or slightly curved, ± flat and triangular, 1–5 mm long, often white hairy in lower half. *Branches* white-tomentose, prickles scattered, sometimes quite unarmed, sometimes ± glabrescent. *Leaves* usually closely set at ends of branches, evergreen, rarely drought deciduous; petiole white-tomentose, 10–85 mm long; stem leaves sometimes bearing 1 or 2 leaf-like, elliptic to obovate pseudostipules at base, 10–40 × 5–20 mm; lamina membranous, elliptic to broadly ovate, obovate, lanceolate or oblanceolate, 50–250 × 20–100 mm, apex usually ± acuminate, base cuneate to sub-rounded, narrowing to petiole and ± unequal-sided, softly textured, markedly discolorous, at first velvety whitish silver-tomentose on both surfaces, soon glabrescent and dark green shiny above, persistently tomentose and rarely with 1 or 2 short prickles beneath, with 9–12 pairs of closely pinnate lateral nerves; margin entire or ± repand-sinuate. *Cymes* terminal or subterminal, becoming lateral, 45–100 mm long, corymbiform to ± paniculiform, dense, 20 to > 60-flowered, densely white-tomentose, sometimes ± glabrescent in fruit; peduncle 15–45 mm long; flowers and fruit often found on same plant, even in one inflorescence. *Flowers* faintly scented, (4)5(6)-merous, ± nodding; pedicels 5–20 mm long, slender, reflexed in flower, in fruit elongated up to 25 mm, ± thickened, erect. *Calyx* 4–6 mm long, campanulate or cyathiform, in fruit saucer-shaped, densely white-tomentose outside, unarmed, ± accrescent; lobes lanceolate-triangular to deltate or ovate-triangular, 1–4 × 1–2 mm, obtuse or acute, sometimes ± acuminate. *Corolla* mauve to blue or purple, rarely white, midvein of each lobe green, rotate; limb 10–16 mm across; lobes lanceolate to oblong, 5–7 mm long, acute to acuminate, tomentose outside, few stellate hairs on midvein and near apex inside, widely spreading to reflexed. *Stamens* yellow; filaments ± 0.5 mm long; anthers 2–4 mm long, linear or lanceolate-elliptic in outline, with small terminal pores, ± incurved. *Ovary* ± globose, ± 1 mm diam., mostly glabrous; style 5–8 mm long, exceeding stamens, straight or ± curved at apex, mostly glabrous. *Fruits* often numerous, ± globose, 5–10 mm diam., smooth, glossy, green ripening through orange to bright red, finally purplish red. *Seeds* numerous, compressed, obliquely reniform to suborbicular in outline, 2.5–3.8 × 2–3 mm, shallowly reticulate, straw-coloured to ± whitish. *Chromosome number*: 2n = 24 (Bukanya-Ziraba 1996).

Taxonomy and diagnostic characters

Solanum giganteum shows some resemblance to the invasive shrub, *S. mauritanium* Scop., which is a native of South America and a Declared Weed in South Africa (Henderson 2001). However, that species has no prickles, has yellow fruit and is very densely velvety or felty hairy in almost all parts. Gonçalves (2005) stated that in *S. giganteum* the very fine snow-white tomentum on the underside of the leaves (tending to become greyish or yellowish in old herbarium specimens), contrasting with the almost glabrous upper surface, is highly distinctive.

Distribution

Solanum giganteum is a widespread, mainly Afro-montane species that has a disjunct distribution in Africa south of the Sahara from Nigeria and Cameroon in the west to Ethiopia in the northeast and down to the Cape Peninsula (Gbile 1979). In southern Africa it has been recorded in Swaziland and South Africa where it occurs in all provinces except the Free State and Northern Cape (Figure 1). It also grows in southern India and Sri Lanka (Deb 1979). Gonçalves (2005) reported that *S. giganteum* is widespread throughout tropical and southern Africa, usually as a highland species, recorded from Ethiopia southwards throughout East Africa to South Africa (Western Cape) and westwards to Nigeria, Cameroon and Gabon, extending to the Canary Islands (Tenerife).

Africa can be divided into 18 major phytochoria according to White's system (1976); *Solanum giganteum* is widespread mainly in the Afro-montane Archipelago-like centre of endemism in western, eastern and southern Africa.

Ecology

In southern Africa *Solanum giganteum* usually grows in dense to partial shade in forests, forest margins, undergrowth and clearings, among trees and often on river banks, in ravines and other moist places. It is common in high rainfall areas, up to 2 000 mm annual rainfall and is a component of woodland and grassland at a wide range of altitudes from 5–2 000 m. It can grow on steep or gentle slopes of all aspects and prefers humus-rich, well-drained brown or red sandy or loamy soils, also stony soils. The geology has been described as granite, Swaziland rocks, middle Ecca sandstone. The flowering time is in summer from October to April. Fruiting specimens have been collected throughout the year, but mainly from December to July; fruit remain on the plant for at least six months. Larger birds such as bulbuls, doves and loeries feed on the fruit, particularly in late winter when food is in short supply. It can also occur as a weed in disturbed areas. Wells *et al.* (1986) listed *S. giganteum* as an occasional ruderal or silvicultural weed that grows in dry to moist soil, in temperate to subtropical areas with summer, winter or all year rainfall. In the *Flora zambesiaca* area, it grows in forest edges, riverine forest and among rocks on granite outcrops; from sea level to 1 650 m (Gonçalves 2005).

Medicinal and horticultural uses

Pappe (1850) reported that the application of the woolly lower surface of the leaves of *Solanum giganteum* (*S. niveum*) to festering ulcers 'cleanses them, and a

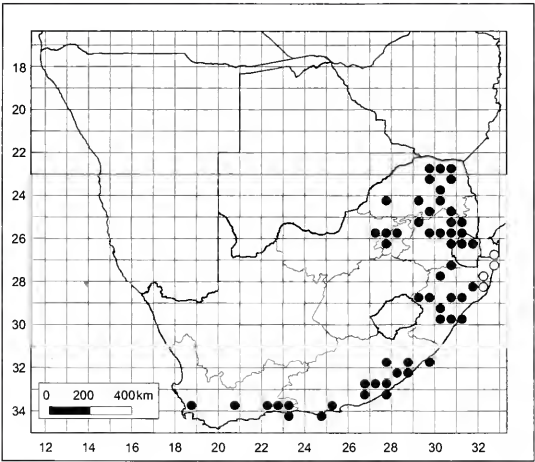


FIGURE 1.—Distribution of *Solanum giganteum*, ●, and *S. goetzei*, ○, in the FSA region.

cure is afterwards effected by applying the upper surface. Hence the Dutch name *Geneesblaren*. The fresh juice of the berries and leaves, when formed into an ointment with lard or fat, is also in use amongst the farmers for the same purpose'. Watt & Breyer-Brandwijk (1962) noted that the Xhosa and Mfengu in the Eastern Cape use the berry to curdle milk. The berry has also been used as a remedy for throat abscesses. Doses of the fresh immature and mature fruit have produced no ill effect in the rabbit. Various parts of the plant have given negative tests for saponin. Fox & Norwood-Young (1982) had a report from Modjadje's Reserve in Duiwelskloof, Limpopo Province, that the berry of this plant is used to curdle milk, and also that the 'red bitter apple' is considered edible. The fruit is used for throat ulcers by the Zulu, Xhosa and Mfengu; the fruit also curdles milk. The leaves are used for festering sores, either directly applied as a dressing or used in ointments (Hutchings *et al.* 1996).

The fruits and leaves of *Solanum giganteum* are used in traditional medicine in Uganda. The leaves are used for the treatment of insomnia and the leaves and fruits for ulcers (Bukunya-Ziraba 1996).

Solanum giganteum is often seen in botanical gardens, especially in the northern hemisphere. It is cultivated in gardens and parks in South Africa and elsewhere as an attractive ornamental shrub or small tree with shiny dark green leaves and showy bright red fruit. It forms a spectacular subtropical bedding plant. It can be used as a background plant in herbaceous borders and also as part of a hedge (Nichols 2002). Seeds germinate easily when cleaned out of the fruit. Seedlings grow rapidly and the plant should be fruiting in the second year. Bailey & Bailey (1977) listed it as a garden subject for southern California. Symon (1981) reported that it is occasionally grown in gardens in Australia, but is not known to be naturalized. In English-speaking countries it is known as African holly.

Chemotaxonomy and chemistry

Maiti *et al.* (1979) found that *Solanum giganteum* contained sufficient quantities of total alkaloids to war-

rant further studies in order to develop it as a source of raw material for the steroid industry. The fruit contained 1.9% solasodine as dry weight. Dan & Dan (1984) reported that solanogantine and solanogantamine (both 3-aminosolanidane derivatives) were isolated as major leaf constituents of *S. giganteum*. Hutchings *et al.* (1996) reported that solanogigine and three 3-aminosolanidanones namely solanogantine, solanogantamine and isosolanogantamine, had been isolated from this plant. Solasodine had been found in the fruit and leaves.

Notes

Gbile (1986) did epidermal studies on *Solanum giganteum* and stated that straight upper epidermal walls had previously been observed in mountain species of other sections of *Solanum*: 'For some unknown reason, most mountain species have straight upper epidermal walls. Some workers, however, observed that straight-walled epidermal cells are commoner in xeromorphic plants than in mesomorphic ones, which typically have undulate cell walls'.

Gbile & Sowunmi (1979) described the pollen of *Solanum giganteum* from Nigeria as subprolate and triangular, polar axis $\pm 30 \mu\text{m}$, equatorial diameter $\pm 25 \mu\text{m}$, with the exine pattern faintly distinct.

Solanum giganteum appears on the official Tree Lists of South Africa (no. 669.4) and Zimbabwe (no. 1014). Various common names for this species have been recorded in southern Africa e.g. healing-leaf tree, *geneesblaarboom* (Afrikaans), *icuba lasendle* (Xhosa). Gonçalves (2005) listed red bitter apple or red bitter berry for the *Flora zambesiaca* area.

2. *Solanum goetzei* Dammer, Botanische Jahrbücher 28: 473 (1901); Wright: 218 (1906); Bitter: 269 (1921); Jaeger: 352 (1985); Beentje: 580 (1994); Gonçalves: 91 (2005). Types: syntypes from Tanzania (Gonçalves 2005).

S. muha Dammer: 186 (1906). Type: syntypes from Tanzania (Gonçalves 2005).

Description (based on Gonçalves 2005)

Erect, much-branched perennial herb or shrublet, rarely scandent, up to 2 m high; prickles absent; sympodia difoliate; hairs stellate, whitish, sometimes violaceous or reddish tinged, minute, \pm sessile, regular, with many short rays. Branches terete, floccose-tomentose at first, gradually glabrescent. Leaves solitary or partly subgeminate; petiole 5–45 mm long, base purple; lamina thin, soft, membranous, lanceolate to obovate, 30–225 \times 10–90 mm, apex acute or acuminate, rarely \pm obtuse, base cuneate, gradually narrowing into the petiole and \pm unequal-sided, somewhat subrepand to scarcely undulate, rarely \pm entire, tending to dry blackish, initially with \pm abundant whitish hairs, soon becoming sparsely hairy to quite glabrous with age, dark green above, underside paler, with 5–9 pairs of lateral nerves. Cymes soon leaf-opposed or leaf-remote, forked 1 or 2 times or rarely unbranched, racemiform, 15–30 mm long, 3–24 flowered, \pm pulverulent-tomentose; peduncle 1–18 mm long; densely stellate-tomentose, rhachis 1–8 mm long. Flowers (4)5-merous, \pm nodding, unscented; pedicels 5–11 mm long, slender, purple, often at first densely hairy,

glabrescent, except at base, in fruit elongated to 16 mm, somewhat thickened distally, ascending or erect. Calyx 2–5 mm long, somewhat accrescent, campanulate or cupular, \pm hairy; 5-lobed, lobes \pm unequal, ovate-triangular to triangular-elongate or broadly obovate, 0.5–3.0 \times 0.5–1.0 mm, acute or mucronate to narrowly long-acuminate, in fruit enlarged to 5 \times 2 mm, finally \pm reflexed. Corolla bluish to pale violet or lilac, sometimes white, campanulate-stelliform; limb 8–15 mm across; deeply 5-lobed, lobes \pm lanceolate, 3–8 \times 1.0–3.5 mm, acute, \pm densely hairy outside mainly on median part, glabrous except for a few stellate hairs scattered along midvein or only near apex inside, erect to reflexed. Stamens 5, subequal; filaments glabrous, 0.5–1.0 mm long; anthers lanceolate-elliptic in outline, 3–5 \times 0.8–1.2 mm, slightly obtuse, \pm emarginate at apex, yellow. Ovary \pm globose, 0.7–1.0 mm diam., glabrous or with few minute glands near apex; style 4.5–8.5 mm long, glabrous, exceeding stamens, often arcuate at apex, glabrous or with few minute glands near base, white; stigma subglobose, green. Fruit globose, 6–10 mm diam., green, shining bright to deep red when ripe, soft. Seeds few, compressed, somewhat obliquely reniform, 3–5 \times 2.5–4.0 mm, surface reticulate-tuberculate, pale yellowish. Chromosome number: unknown. Figure 2.

Taxonomy and diagnostic characters

Solanum goetzei is closely related to *S. schumanianum* Dammer from the upland forests of Kenya and Tanzania and also to *S. anomalum* from West Africa. This is the species which Ross (1972) referred to as *Solanum* sp. no. 30 (Ward 3840) from Tongaland. The shrubby, unarmed habit and thin, soft, dark green, glabrescent lanceolate to obovate leaves as well as the very large seeds of *S. goetzei* are unique among the species of *Solanum* found in southern Africa.

Distribution

This species has been recorded from Kenya, Tanzania, Malawi and Mozambique down to the Ingwavuma, Ubombo and Hlabisa (Tongaland) Districts of KwaZulu-Natal (Figure 1). According to White's system (1976), *Solanum goetzei* is endemic to the Zanzibar-Inhambane and Tongaland-Pondoland regional mosaics; these form an intermittent strip of forest along the east coast of Africa.

Ecology

Whalen (1984) observed that his *Giganteum* group is divided between montane forest and savanna habitats in Africa. The species with difoliate sympodia (e.g. *Solanum goetzei*) are probably derived within the group and occupy open savannas, grasslands and forest margins. According to Jaeger (1985), this species grows in disturbed or open places in the forests of East Africa between a few metres above sea level and 1 200 m altitude. Beentje (1994) reported that *S. goetzei* grows in forest, riverine forest and coastal bushland in Kenya. In the *Flora zambesiaca* area, Gonçalves (2005) reported that this species grows in dry forest margins and the understorey, *Combretum-Terminalia* and mopane woodland, savanna woodland and coastal bushland, sometimes on termite mounds or around granite outcrops, ruderal places and other areas of disturbance, particularly along



FIGURE 2.—*Solanum goetzei*, A–D, M.C. Ward 1328 (PRE); C.J. Ward 3840 (PRE). A, habit, $\times 1$; B, flower, $\times 3$; C, fruit, $\times 1.5$; D, seed, $\times 1.5$. Artist: G. Condy.

roads. In South Africa it grows on well-drained sandy soil at forest margins, in clearings and along forest paths, also in woodland, in deep as well as light shade, from about sea level to 100 m altitude. In KwaZulu-Natal, flowering and fruiting material have been collected from November to May.

Medicinal and other uses

Dammer (1901) cited Goetze who wrote that the roots are used as medicine against toothache. Magogo & Glover 1030 (PRE) from Tanzania noted that 'a hot poultice made from the leaves is used to reduce swellings and to draw out abscesses; also used to draw out whitlows on the fingers'. Jaeger (1985) stated that *Solanum goetzei* is

used as a leaf vegetable in Kenya, while Beentje (1994) noted that, also in Kenya, a poultice of the leaves is used to draw out abscesses.

Toxicity and chemistry

The chemistry and toxicity, if any, of this plant have not yet been investigated.

3. *Solanum tettense* Klotzsch in Peters, Naturwissenschaftliche Reise nach Mossambique, Botanik 6,1: 237 (1861); Dammer: 355 (1895); Wright: 212 (1906); Bitter: 276 (1921); Gonçalves: 86 (1997); Gonçalves: 92 (2005). Type: Mozambique, Tete Prov., Tete ('Tette'), *W. Peters s.n.* (B, holo.; BM, K, iso.) [Gonçalves 1997].

Description (based on Gonçalves 1997)

Erect, semi-woody herb or shrub, laxly to much branched from base, sometimes scrambling, up to 3 m high; covered with grey to yellowish/brownish dense tomentum of \pm sessile, short-radiate, stellate hairs, or bearing a long central ray, sometimes apically glandular, minute to large hairs all over (at least when young), and also of simple, apically glandular, spreading hairs sparsely intermixed, then pruinose, finally glabrous on some parts; prickles few to many, laterally compressed, broad-based, straight or curved, \pm stout, pale yellow to brown, 1–5 mm long, stellate-tomentose in lower half or glabrous, sometimes absent; sympodia difoliate. *Stems and branches* \pm terete, glabrescent, bark smooth to \pm rough, pale yellow/brown-grey to dark grey, sometimes with conspicuous lenticels. *Leaves* solitary or appearing geminate, sometimes closely set at terminals; petiole 4–40 mm long, densely to \pm hairy, prickles usually absent; lamina membranous, papery, leathery or \pm fleshy, \pm discolourous, obovate to lanceolate, 15–140 \times 5–80 mm, apex obtuse-rounded to \pm acuminate, base rounded to cuneate, narrowing into the petiole, \pm unequal, with 4–7 pairs of curved-ascending lateral nerves, greyish/yellowish below, tomentose to subglabrescent; green above, stellate-hairy to glabrescent; rarely 1–few prickles on midrib; margins repand-sinuate to entire. *Inflorescences* terminal, cymes becoming lateral, unbranched to several times forked, 30–50 mm across, few to many-flowered, often dense; peduncle 0–30 mm long; rachis 7–45 mm long. *Flowers* 4 or 5(–7)-merous, \pm nodding; pedicels 3–13 mm long, elongated in fruit, up to 18 mm long, \pm thickened distally, erect. *Calyx* greyish/yellowish, densely to \pm hairy outside, 2.5–6.0 \times 3–6 mm, \pm accrescent, campanulate or cupular; lobes lanceolate to broadly obovate, 1.0–3.5 \times 1–2 mm, apically rounded, long-acuminate, 5 \times 2 mm in fruit, \pm reflexed, glabrous inside. *Corolla* white to mauve, blue, violet or purple, 6–13 mm long, \pm rotate; limb 6–22 mm across, lobes oblong-ovate to linear, 4–11 \times 1.5–4.5 mm, apex acute/obtuse, greyish or whitish hairy outside, mainly on median part, mostly glabrous inside, erect to reflexed. *Stamens* \pm equal, glabrous, exserted; filaments 0–1.5 mm long, whitish; anthers yellow to orange-yellow, 4–7 mm long, \pm lanceolate in outline, opening by 2 small, oblique pores. *Ovary* globose/ellipsoid, 1.0–1.5 mm diam./length, glabrous; style 5–11 mm long, slender, longer than stamens, straight or \pm apically curved, glabrous; stigma small, capitate, obtuse or slightly 2-lobed. *Fruits* globose, 5–10 mm diam., green turning yellow-brown to deep red when ripe, fleshy, glossy, glabrous, in axillary clusters or pseudo-terminal cymes. *Seeds* numerous, compressed, obliquely reniform, reticulate-tuberculate, 3.0–3.5 \times 2–3 mm, \pm pale yellow, drying blackish. *Chromosome number*: $2n = 24$ (Bukenya-Ziraba 1996).

Key to varieties (from Gonçalves 1997)

- Stellate hairs often bearing a long central ray intermixed with simple, long, spreading, \pm abundant hairs, both apically glandular. var. *tettense*
 Stellate hairs eglandular, sometimes intermixed with simple, short, abundant, apically glandular hairs var. *renschii*

3a. var. *tettense*

See description above.

3b. var. *renschii* (Vatke) A.E. Gonç. in Kirkia 16,1: 89, fig. 1 (1997); Gonçalves: 93, t. 18 (2005). Type: Kenya, Central Prov., Machakos or Kitui Dist., Ukamba (Ukambani area), J.M. Hildebrandt 2735 (B, holo.; W, iso.) [Gonçalves 1997].

S. renschii Vatke: 328 (1882). Type: as above.

S. kwebense N.E.Br. ex C.H. Wright: 225 (1906). Types: Botswana, Ngamiland, Kwebe Hills, *Lugard* 50 (K, lectosyn.), *Mrs Lugard* 62 (K, syn.) [Gonçalves 1997].

S. luederitzii Schinz: 264 (1912). Type: Namibia, Hereroland, *Lüderitz* 1a [Podlech & Roessler 1969].

S. upingtoniae Schinz: 266 (1912). Type: Namibia, Amboland, Oschando, *Schinz* 868 [Podlech & Roessler 1969].

S. tenuiramosum Dammer: 244 (1912). Type: Botswana, Masalan-yane Pan (Massaringani Vlei), *Seiner* II.271 (B, holo.) [Gonçalves 1997].

S. chondropetalum Dammer: 335 (1915). Type: Namibia, Damara-land, Naugubais, *Dinter* 1448 [Podlech & Roessler 1969].

Taxonomy and diagnostic characters

Wright (1906) and Bitter (1921) recognized *Solanum kwebense*, *S. renschii* and *S. tettense* as three distinct species. Lebrun & Stork (1997) recognized both *S. kwebense* and *S. renschii* (*S. tettense*), whereas Podlech & Roessler (1969) recognized only *S. kwebense*. Studies by Gonçalves (1997) revealed that both the vegetative and inflorescence characters of these three species show a strong intergradation. Therefore these taxa constitute a single polymorphic species with great morphological and ecological diversity. *S. tettense* is the correct name for this species. The two varieties cannot be separated on geographical or ecological terms.

The diagnostic characters of *Solanum tettense* in relation to the other two members of section *Giganteiformia* in southern Africa, are outlined in the key above. *S. tettense* can be distinguished from other *Solanum* species in the same area by its pedunculate cymes and entire, discolourous leaves without prickles.

Gonçalves (2005) observed that *Solanum tettense* is somewhat intermediate between section *Giganteiformia* and section *Oliganthes*; it is relatively common in the *Flora zambesiaca* area, but is easily overlooked or misidentified.

Distribution

Solanum tettense is widespread throughout tropical and southern Africa; it is recorded from Ethiopia southward through East Africa to South Africa, and westward to Zaire, Angola, Botswana and Namibia. In southern Africa, var. *renschii* is found in Namibia, Botswana and the Limpopo and Mpumalanga Provinces in South Africa (Figure 3). In southern Africa var. *tettense* occurs only in Botswana (Figure 3). According to White's system (1976), *S. tettense* is widespread in the Somalia-Masai regional centre of endemism, but is also found in the Zambezi regional centre of endemism and in the Kalahari-Highland regional transition zone.

Ecology

In southern Africa, *Solanum tettense* grows on well-drained red or brown, shallow to deep, dry to damp, sandy or loamy soils that can be stony or quartzitic. It is often found on weathered granite, gneiss or dolomite outcrops and inselbergs, also on calcified dolomite or calcareous soils. This species grows on flat areas such as the edges of pans or on flood plains, but also on moderate or steep slopes of all aspects, on sandy dunes and rocky hillsides. It has been collected on termitaria, in disturbed and overgrazed areas, also on roadsides. *S. tettense* grows in full sun but more often in the semi-shade or shade of taller shrubs or trees, also in dense thickets. Larger leaves develop in shady habitats. It becomes invasive in overgrazed vegetation with a reduced grass cover.

Solanum tettense grows in vegetation types ranging from grassland and savanna to various kinds of deciduous or evergreen woodland and bushland. Trees and shrubs such as *Acacia*, *Boscia*, *Combretum* and *Grewia* are commonly associated with *S. tettense*.

The rainfall in the distribution area of *Solanum tettense* var. *renschii* in southern Africa, is 400–1 000 mm per year and it grows at an altitude of 335–1 370 m. Flowering time: October to March, mainly from January to March. Fruiting time: November to May, mainly from January to April.

Gonçalves (2005) stated that in the *Flora zambesiaca* area, including Botswana, *Solanum tettense* grows in mixed woodland, mopane and wooded grassland or thickets, extending into miombo on termite mounds, also streambeds, rocky places and areas of disturbance in moist and semi-arid situations at 100–1 600 m altitude.

Medicinal and other uses

Maguire noted on the label of his specimen *B. Maguire* 2272 in PRE (collected at Karakuise in Namibia in 1953), that the fruits provide ingredients for the arrow poison of the Khoi-San (Bushmen). Barnard noted on the label of his specimen *Barnard* 153 in

PRE (collected in Sekhukhuneland near Lydenburg in Mpumalanga Province in November 1934), that ‘the roots are cooked and placed in a calabash (fruit of *Lagenaria siceraria*), in which a small opening has been made. The calabash is then fastened over a suppurating wound to draw out the pus’. Collectors have noted that *Solanum tettense* is eaten by the large antelope, the eland. The Tswana common name *mwarasipe* is listed by Miller on the label of his specimen *B/469* in PRE, collected in Botswana. The Kamba in Kenya use the roots against typhoid (Beentje 1994).

Toxicity

Pienaar *et al.* (1976) proved that *Solanum tettense* can be poisonous to cattle. A neurological disease of cattle (named *maldronksiekte* by farmers), occurring in a localized, badly overgrazed area of the Limpopo Province of South Africa, was experimentally reproduced at Onderstepoort Veterinary Institute by feeding *S. tettense* var. *renschii* plants (known as *rooibessie* among farmers) to cattle. According to Vahrmeijer (1981), the disease is characterized by temporary loss of balance and transient epilepsy-like seizures precipitated by a variety of stimuli, such as exercise, handling (dipping and loading) and fright. The animal staggers about with an extended and slightly twisted neck, and in serious cases falls to the ground. After a while it rises again as if nothing were wrong. Losses are suffered when animals are injured during falls. When not disturbed, most affected animals appear to be completely normal. The poison affects the central nervous system and causes permanent damage to, and interferes with the function of the cerebellum. *Maldronksiekte* is a chronic intoxication with a latent period of at least 50 days between ingestion of the plant and the appearance of typical clinical signs. Donkeys, goats and sheep are apparently not affected by the poison. The chemistry of *S. tettense* var. *renschii* was not investigated in the above study.

SPECIMENS EXAMINED
(southern Africa only)

Specimens held at PRE, unless otherwise indicated. The numbers in brackets indicate the identity of the specimens: (1) *Solanum giganteum*; (2) *S. goetzei*; (3a) *S. tettense* var. *tettense*; (3b) *S. tettense* var. *renschii*.

Abner 71 (3b). Acocks 11519 (1). Acocks & Hafström 1376 (3b). Allen 346 (3b). Ankiewicz 8 (2).

Barnard 153, 529 (3b). Barnard & Mogg 857, 1013 (1); 1082 (3b). Bayliss 1132, 7052 (1). Brink 294 (1). Bruce 46 (3b). Buerger 1020 (3b). Buitendag 1162 (1) Lowveld Botanical Garden, PRE. Burgoyne 3076, 3423, 3241 (3b).

Codd 5921 (1); 4147, 5984, 8884 (3b). Coetzee 1154 (1). Compton 25550, 30071 (1). Crampton 113 (1). Curson 465, 481, 526 (3b).

Davidse 6814 (1). Devenish 1580 (1). De Winter 2817 (3b); 8273 (1). De Winter & Leistner 5095, 5516 (3b). Dinter 5312, 7448 (3b). Dlamini s.n. PRE31390 (1).

Edwards 1318 (1).

Flanagan 472 (1).

Galpin 2854, 7815, 9039 (1). Germishuizen 7540, 7765, 9552, 9770 (3b). Gerstner 5747 (1); 6047 (3b). Giess 9277, 12592, 15016 (3b). Giess & Müller 11808, 13977 (3b). Giess, Watt & Snyman 11129 (3b). Giffen 1086, 1437 (1). Goldblatt & Manning 8399 (1).

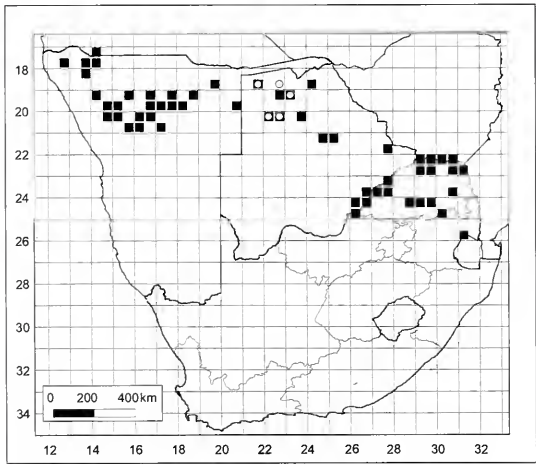


FIGURE 3.—Distribution of *Solanum tettense* var. *tettense*, ○, and var. *renschii*, ■, in the FSA region.

Hansen 3355 (3b). Harbor TRV14089 (3b). Hardy, Retief & Herman 5363 (1). Haynes 967a (1). Hemm 597 (1). Henning 5 (3b). Hilner 475 (1). Hines 638 (3b). Holt 135 (1). Hobohm PRE41601 (3b). Hoffmann LH204 (3b). Hulley, Olckers & Hill 379 (3b). Huntley 1049 (3b); 1306 (1).

Jacobsen 729, 2906 (1); 2200 (3b). Junod 4291 (1).

Kerfoot & Falconer 41, 156 (3b). Killick 401, 1707 (1). Kluge 718 (1). Lowveld Botanical Garden, PRE. Kotze 84 (3b).

Lawson 324, 340 (2) NH. Leendertz 554, 689 (1). Leistner 3160 (3b). Leistner, Oliver, Steenkamp & Vorster 41 (3b). Lent 46 (3a). Le Roux 819 (3b). Liebenberg 2950 (1); 4821, 4918 (3b). Louw 15 (1).

MacDevette 883 (2) NH. Maguire 2272 (3b). Mannheim & Mannheim CM530 (3b). Marloth 4311, 5677 (1). Marriott PRE22643 (1). Meeuse 10457 (3b). Merxmüller & Giess 30455 (3b). Meyer 1031 (1). Miller B/469, B/1197 (3b). Mogg 11511, 12455, 15004, 36077 (1). Moll & Morris 693 (1). Morris 711 (1). Moss 2085 (3b). Morze 2085 (1). Müller & Biegel 2302 (3b). Müller & Scheepers 225 (1). Munro TRV23163 (1).

Naude 1/94 (3b). Nienaber EN325 (1).

Obermeyer TRV28143, TRV29223 (1). Obermeyer, Schweickerdt & Verdoorn 57 (3b). Onderstall 916 (1). Lowveld Botanical Garden, PRE.

Paterson TRV25847 (1). Pegler 709, 2890 (1). Pentz 299 (1). Pienaar 367 (3b). Pole Evans 238 (1); 1933, 4536 (3b). Pott PRE59768 (1). Prior PRE41307 (1).

Raal 809, 1388 (3b). Repton 621, 1005 (1). Rodin 3959, 4519 (1). Rogers PRE3791, 14455, 23467 (1).

Scheepers 676 (1). Schoenfelder 1004 (3b). Sim 1272, 20000, 20006 (1). Smith 357A, 6868 (1); 3101 (3b). Stalmans 555 (1). Stephens 7 (1). Story 6481 (3b). Straub 158 (3b). Streyl 3477 (3b); 3843 (1); 4786 (2) NH, PRE.

Theron 1511 (1); 2879 (3b). Thode A1292 (1). Thorncroft TRV3930 (1). Tölken & Hardy 894 (3b).

Van der Schijff 3503 (3b); 4600, 4874, 7357 (1). Van der Spuy 10 (3b). Van Rooyen 3401 (3b). Van Son TRV29022 (3b). Van Vuuren 89 (1). Van Warmelo 275 (3b). Van Wyk 3681 (1). Van Wyk & Van Wyk 1599 (1). Venter 3795 (1); 12820 (3b). Volk 966, 2911 (3b).

Wahl TRV15368 (1). Ward 87, 399, 1328 (2) NH; 608, 2961 (1); 3226, 3840, 7053 (2). Watt & Breyer-Brandwijk 1027 (1). Welman 432 (1). Westfall 1009 (1). Wild & Drummond 6857 (3a).

Zwanziger 758 (3b).

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Two new species of *Babiana* (Iridaceae: Crocoideae) from western South Africa, new names for *B. longiflora* and *B. thunbergii*, and comments on the original publication of the genus

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Keywords: *Babiana* Ker Gawl., new names, new species, range extension, replacement names, section *Teretifoliae*, South Africa, taxonomy

ABSTRACT

Babiana symmetrantha and *B. virescens* are two new species of section *Teretifoliae* of this southern African genus, now comprising 90 species. *Babiana symmetrantha* blooms in August and early September and is restricted to the summit of the Langberg, which lies along the border of Namaqualand and the western Karoo near Loeriesfontein. One of only three species of the section with radially symmetric flowers, it is acaulescent and has linear, almost plane leaves covered with long hairs, a perianth tube 45–60(–75) mm long, and subequal, spreading tepals. *Babiana virescens* blooms in early winter, in May and June, and occurs in seasonally moist open ground on gentle slopes and valley bottoms in southern Namaqualand between Nuwerus and Bitterfontein. It is distinguished by the slightly twisted, oblong leaves with thickened, pale margins, and the glabrous cataphylls and leaf sheaths. The stem, which may be produced up to 100 mm above the ground, is simple or has a single short branch and the spikes bear 2–6 greenish flowers, the tepals of which are unusually narrow and longer than the perianth tube. We also propose a new name, *B. tubaeformis*, for the homonym *B. longiflora*, and provide a new combination *B. hirsuta* based on the 1783 name *Antholyza hirsuta* Lam., which replaces *B. thunbergii* Ker Gawl. (1804). Lastly, we present an argument that *Babiana* is correctly attributed to Ker Gawler alone and that its protologue dates from 1802, contrary to some current authorities.

INTRODUCTION

Botanical exploration in western southern Africa since the completion of our monograph of *Babiana* in February 2005 (Goldblatt & Manning 2007) has resulted in the discovery of two additional species of this southern African and largely western South African genus. Including the new species described below, *Babiana* now comprises 90 species, all but two of which are endemic to the southern African winter rainfall zone. The new species are *B. symmetrantha*, from the isolated Langberg massif between Namaqualand and the western Karoo, which is unusual in its linear leaves and radially symmetric flower with an elongate perianth tube 45–60(–75) mm long, and *B. virescens* from the granite hills of southern Namaqualand, which has narrow tepals, usually a well-developed aerial stem, and unusual, twisted leaves with thickened, hyaline margins. Both fall in section *Teretifoliae* G.J.Lewis emend. Goldblatt & J.C.Manning. Formal descriptions, illustrations, and a discussion of the biology and relationships of the two species are presented below. Recent collections have also extended the known range of *B. ambigua*, with a first record for the Northern Cape. Then, two names in current use in the genus, need to be replaced. *Babiana longiflora* is a homonym, and we propose the replacement name, *B. tubaeformis*, for the species, and *Antholyza hirsuta* Lam. (1783) is a legitimate earlier epithet for *B. thunbergii* Ker Gawl. (1804), hence we provide the new combination *B. hirsuta* for this common plant of the

west coast of South Africa. Finally, the question of the author of the genus is re-examined in the light of some confusion as to the correct citation.

TAXONOMY

***Babiana symmetrantha* Goldblatt & J.C.Manning, sp. nov.**

Plantae 100–200(–300) mm altae foliis inclusis, caule subterraneo vel supra terram producto simplici vel uniramoso, foliis anguste linearibus usque ad 200 mm longis 2–5(–8) mm latis, spica 2- vel 3-flora, bracteis viridibus, 30–35 mm longis bractea interiore ad apicem furcata, floribus hypocrateriformibus actinomorpha violaceis basem versus colore atrovioleaceo notatis tubo externe albo, die odorem *Violae* exhalantibus, tubo perianthii 45–60(–75) mm longo, tepalis aequalibus patentibus lanceolatis (22–)28–35 × 5–7 mm, filamentis ± 10 mm longis, antheris ± 5 mm longis ad apicem connatis, ovario glabro, stylo diviso infra basem antherarum, ramis styli 4–5 mm longis.

TYPE.—Western Cape, 3019 (Loeriesfontein): summit plateau of the Langberg among dolerite boulders, (–DB), 5 September 2006, Goldblatt & Porter 12772 (NBG, holo.; K, MO, PRE, S, iso.).

Plants 100–200(–300) mm high, including leaves, forming clumps. *Corms* globose, 8.5–11.0 mm diam., with fibrous tunics. *Stem* subterranean or reaching above ground when growing through vegetation, producing slender cormlets in lower axils, simple or 1-branched, enclosed by neck of brittle, brown fibres. *Leaves* basal, linear, exceeding flowers, up to 200 × 2–5(–8) mm, flat, sparsely pubescent. *Spike* 2- or 3-flowered; bracts green,

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becoming dry and light brown at tips, 30–35 mm long, finely pubescent, long-attenuate, inner slightly shorter than outer, forked apically and 2-keeled. *Flowers* actinomorphic, salver-shaped, tepals outspread when fully open, violet with darker violet marks near base of tepals, sometimes lower lateral tepals with white marks outlined with violet, sweetly scented of violets during day; perianth tube cylindric, 45–60(–75) mm long, straight, slightly expanded in upper 10 mm, hollow above but with thick walls tightly enclosing style in lower half, containing nectar; tepals subequal, lanceolate, (22–)28–35 × 5–7 mm, inner tepals narrower than outer. *Stamens* symmetrically arranged, erect; filaments ± 10 mm long, exerted ± 7 mm, purple; anthers arched inward, ± 6 mm long, contiguous at tips, white; pollen white. *Ovary* glabrous; style erect, purple, dividing below base of anthers, style branches 4–5 mm long, expanded in upper third, arching between anthers. *Capsules* and *seeds* unknown. *Flowering time*: mid-August to mid-September. Figure 1.

Distribution and ecology: restricted to the summit plateau of the Langberg west of Loeriesfontein in the Northern Cape (Figure 2), *Babiana symmetrantha* appears to be a narrow geographic and edaphic endemic. The Langberg, an isolated, flat-topped mountain ± 1 000 m in elevation, is capped by a dolerite sill and *B. symmetrantha* occurs in heavy red clay among dolerite boulders in succulent Karoo vegetation.

Discussion: the species has inner floral bracts that are forked at the apex, placing it in section *Teretifoliae*, one of the three sections of the genus currently recognized (Goldblatt & Manning 2007). It is one of just three species of the section with a radially symmetric perianth, the others being *Babiana pygmaea* (Burm.f.) Baker and *B. radiata* Goldblatt & J.C.Manning, but *B. symmetrantha* is distantly allied to these species and is more likely related to the *B. framesii* L.Bolus–*B. sambucina* Ker Gawl. group, which also has an underground stem and elongate perianth tube, but bilabiate and often scented flowers. Apart from the radially symmetric flowers, *B. symmetrantha* is unusual in its linear, almost plane leaves that show little hint of the pleating present in most species. We assume that the long-tubed flowers are adapted for pollination by long-proboscid flies as they have the long, hollow perianth tube associated with the *Prosoeca peringueyi* pollination system (Goldblatt *et al.* 1995; Manning & Goldblatt 1996; Goldblatt & Manning 2000). Flowers in this guild are typically unscented but floral fragrance is present, and possibly atavistic, in a few species, including *B. framesii* and some populations of *B. sambucina* subsp. *longibracteata* (G.J.Lewis) Goldblatt & J.C.Manning.

Babiana symmetrantha was only discovered in 2006 when we mounted an expedition to explore the botany of the Langberg. The mountain stands some 1 000 m high, well above the surrounding low granite domes and sandy flats of eastern Namaqualand and the western Karoo. Geologically the mountain consists of rocks of early Karoo System age, mostly bedded Ecca shales, intruded by dolerite sills. The flat, slightly tilted summit plateau consists of weathered dolerite boulders and heavy, red



FIGURE 1.—*Babiana symmetrantha*, Goldblatt & Porter 12772 (NBG): A, whole plant. B, C, flower: B, front view, C, side view. D, outer (left) and inner (right) floral bracts. Scale bar: 10 mm. Artist: John Manning.

clay soil derived from weathered dolerite. The vegetation above the granite belt at the base of the mountain resembles that of the western Karoo rather than that of Namaqualand. *Ixia rapunculoides*, *Moraea bifida* and *M. tripetala* (Iridaceae) are three of the more common geophytes on the plateau, and occur also on the Bokkeveld Plateau and on doleritic clays east of Loeriesfontein, both sites ± 70 km to the southeast. Another disjunct is *Boophone haemanthoides* (Amaryllidaceae), which also occurs on dolerites of the Bokkeveld Plateau as well as on the western coastal plain of Western Cape Province. The fairly common Namaqualand species, *Babiana flabellifolia*, occurs at lower elevations, together with *Moraea serpentina* and *M. schlechteri*, both of which

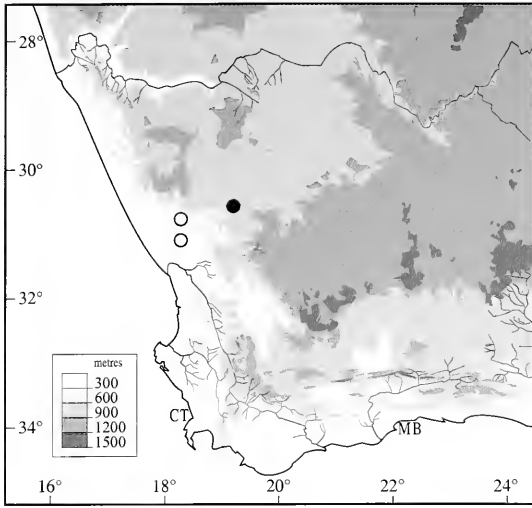


FIGURE 2.—Known distribution of *Babiana symmetrantha*, ●; and *B. virescens*, ○.

are common in Namaqualand but rare or absent from the western Karoo to the east. The Langberg is linked to the western Karoo highlands by a second isolated range, the Kubiskou Mountains, a short distance west of Loeriesfontein. The vegetation of this range has not been well explored but its lower and middle slopes have characteristic western Karoo species such as *Babiana crista*, *B. spathacea* and *Ixia marginifolia*, whereas *I. sobolifera* and *Geissorhiza heterostyla* grow on the dolerite-topped summit. Of these species, only the two last named occur on the Langberg.

Additional specimen examined

NORTHERN CAPE.—3019 (Loeriesfontein): summit plateau of the Langberg among dolerite boulders, (–DB), 16 September 2006, Goldblatt & Porter 12839 (MO, NBG).

***Babiana virescens* Goldblatt & J.C.Manning, sp. nov.**

Plantae 70–200 mm altae, caule usitate eramoso, foliis lanceolatis minute velutinis leviter plicatis marginibus incrassatis anguste hyalinis, spica 3- ad 7-flora arcuata, bracteis viridibus 20–30 mm longis subaequalibus, bractea exteriore velutina bractea interiore ad apicem furcata, floribus zygomorphis pallide viridi-griseis tepalis inferioribus flavis purpureo-notatis odoratis, tubo perianthii 18–23 mm longo oblique infundibuliformi, tepalis inaequalibus tepalo dorsali 32–38 × 6.5–8.0 mm, inferioribus 25–30 × ± 4–5 mm, filamentis suberectis 12–16 mm longis, antheris 7–8 mm longis, ovario glabro, ramis styli 4–6 mm longis.

TYPE.—Western Cape, 3018 (Kamiesberg): Farm Kama-gap, 1 km along Bitterfontein–Pofadder road, hillside on S side, (–CD), 26 May 2007, Manning 3093 (NBG, holo.; MO, iso.).

Plants 70–200 mm high. *Corm* subglobose, 15–20 mm diam., outer tunics of fine-textured, reticulate fibres, persisting as loose neck. *Stem* reaching to ground level or up to 100 mm above ground, erect but strongly

inflexed above uppermost leaf sheath, unbranched or with one short branch, glabrous below, becoming velvety near spike; cataphylls and leaf sheaths glabrous. *Leaves* 3 or 4, oblong to lanceolate, slightly twisted distally, blade suberect at ± 30°, 40–100(–150) × (5–)10–18 mm, thinly velvety, lightly pleated, midrib and margins slightly thickened, margins hyaline, minutely hairy; seedling leaves linear-lanceolate and coiled, hairy. *Spike* 3–7-flowered, arching horizontally, secund; bracts green with brown tips, outer ovate, 20–30 mm long, margins narrowly hyaline, thinly and minutely velvety, especially distally, apical margins markedly ciliate, truncate or emarginate-apiculate, inner bracts about as long as outer, forked for 5–8 mm, with broad hyaline margins in lower half. *Flowers* zygomorphic, pale grey-green or flushed with greyish lilac, lower lateral tepals with yellowish green median blotches and purple streaks, with sweet, spicy scent; perianth tube obliquely funnel-shaped, narrow part hollow to base, containing nectar, 18–23 mm long; tepals unequal, narrowly lanceolate, margins crispulate, dorsal suberect, recurving distally, 32–38 × 6.5–8.0 mm, upper laterals narrower, joined to lower tepals for 5–7 mm forming lip, lower tepals 25–30 × 4–5 mm. *Stamens* unilateral; filaments suberect, 12–16 mm long; anthers 7–8 mm long, whitish. *Ovary* glabrous; style dividing opposite middle third of anthers, style branches 4–6 mm long. *Capsules* subglobose, 8–9 mm long. *Seeds* unknown. *Flowering time*: late May to early June, fruiting in August to September (Figure 3).

Distribution and ecology: a local endemic of southern Namaqualand, between Nuwerus and Bitterfontein, where it occurs on granite hills on gentle slopes and valley bottoms in gravelly ground in open, succulent karroid shrubland, sometimes between granite outcrops but never wedged in rock crevices (Figure 2).

Discussion: *Babiana virescens* accords with section *Teretifoliae* in its apically forked inner floral bracts but is unusual in its well-developed aerial stem, since most members of the section have the stem reaching only shortly above the ground or completely subterranean. The bilabiate flowers stand out in having particularly narrow, ± linear tepals, the dorsal 32–38 × 6.5–8.0 mm and the remaining tepals 4–5 mm wide. Although quite large, the greenish flowers are not conspicuous but have a characteristic spicy-acrid, chemical odour that is common in the genus. The flowers close at night and cease to produce fragrance, lasting four or five days when not pollinated.

This new species may be most closely allied to *Babiana torta* G.J.Lewis and *B. namaquensis* Baker on account of the slightly coiled leaves and early flowering but it is easily distinguished from them by its greenish flowers with particularly narrow tepals and by the subglabrous or very short-hairy leaves and the aerial stem up to 100 mm high. The slightly thickened leaf margins are most evident in herbarium specimens, drying whitish or pale. Both blue-flowered *B. torta* and pale mauve-to white-flowered *B. namaquensis* have distinctly hairy leaves without conspicuous margins and typically occur in rock outcrops, granite in the former but often limestone in the latter, with their corms wedged in crevices. *Babiana torta* typically occurs in granite rock outcrops, whereas *B. virescens* always occurs in open ground and

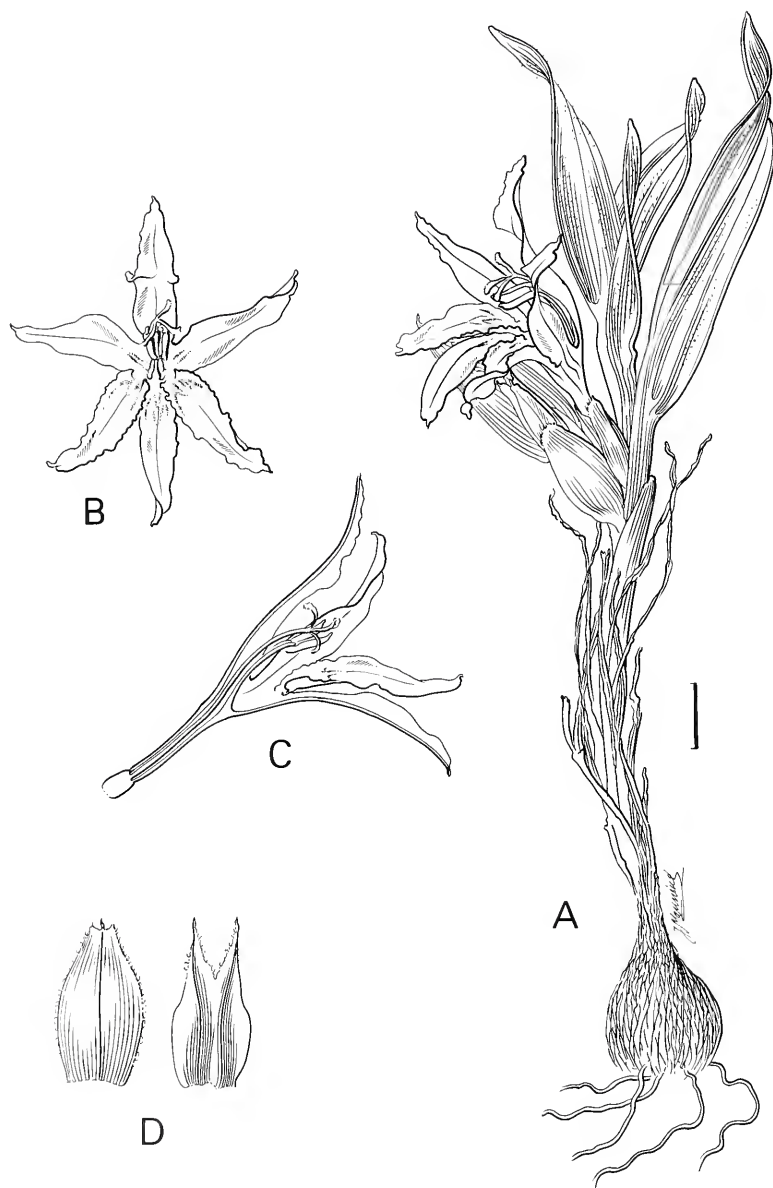


FIGURE 3.—*Babiana virescens*, Manning 3093 (NBG): A, whole plant. B, C, flower: B, front view, C, side view. D, outer (left) and inner (right) floral bracts. Scale bar: 10 mm. Artist: John Manning.

relatively deep, loamy gravel. Both species have been collected within a few kilometres of each other east of Bitterfontein, confirming their status as distinct species.

Babiana virescens shares grey-green flowers having unusually narrow tepals with *B. gariensis* Goldblatt & J.C.Manning, a poorly known species from northern Namaqualand. This species is acaulescent, has leaves without evidently thickened margins, and flowers with a perianth tube 20–24 mm long, slender below, curving outward and wider in upper 7 mm, and a dorsal tepal $28\text{--}32 \times \pm 5$ mm. Additional material in flower is needed to better understand this apparently rare Richtersveld endemic that is currently known from three sites, Kocskop in the Richtersveld National Park in the north, Cornellsberg, and from Grasvlakte in the southern Richtersveld. The larger dorsal tepal, $32\text{--}38 \times 7\text{--}8$ mm,

and aerial stem readily distinguish *B. virescens* from *B. gariensis*.

Babiana virescens appears to have first been collected in May 1993 by Cape Town botanist Dee Snijman. The collection was referred to *B. torta*, at the time poorly documented (Lewis 1959) but now known to be a relatively common, early flowering species of southern and central Namaqualand (Goldblatt & Manning 2007), which typically has pale blue flowers with broad tepals. Our first collection of *B. virescens* (Goldblatt & Porter 12145) was also referred to *B. torta* in our monograph of the genus, leading us to describe the leaves of that species as variously hairy to almost hairless. With these specimens removed from *B. torta*, the leaves of that species are now known to be uniformly softly hairy.

Additional specimens examined

WESTERN CAPE.—3018 (Kamiesberg): Kliprand road close to turnoff from Bitterfontein, (–CD), gentle slope, 19 May 1993, *Snijman 1304* (NBG). 3118 (Vanrhynsdorp): 3 km south of Nuwerus, road to Vredendal, granitic soil in valley bottom, (–AB), 2 September 2002 (fruiting), *Goldblatt & Porter 12145* (MO, NBG), [flowered Portland, USA, December 2005, *Goldblatt & Porter 12145A* (MO), 16 September 2006 (fruiting), *Goldblatt & Porter 12853* (MO)].

The two new species may be accommodated in the key to section *Teretifolia* of *Babiana* in Goldblatt & Manning (2007: 12, 13) as follows:

- 2a Stem aerial; flowers cream-coloured to pale yellow with brown to dull purple centre; leaves lanceolate to ovate; perianth tube 15–25 mm long; ovary hairy *B. pygmaea*
 2b Stem subterranean; flowers blue or violet; leaves linear; perianth tube > 25 mm long; ovary hairless:
 2a' Flowers with red centre and throat; perianth tube 30–75 mm long; tepals 10–12 mm wide; anthers violet. *B. radiata*
 2b' Flowers without red centre; perianth tube 45–75 mm long; tepals 5–7 mm wide; anthers white *B. symmetrantha*
 32a Flowers pale greyish green; leaf margins thickened. *B. virescens*
 32b Flowers pale blue, mauve or whitish; leaf margins usually unthickened;

RANGE EXTENSION

Babiana ambigua (Roem. & Schult.) G.J.Lewis

The range of *Babiana ambigua* is largely coastal, extending from near Lambert's Bay in the north to Riversdale in the southeast (Goldblatt & Manning 2007). Populations also occur inland on the Gifberg, the Cold Bokkeveld and the Olifants River Mountains. Wherever it has been collected, the species occurs on coarse sand or sandy granitic gravel. A new collection from sandy ground at the top of Botterkloof Pass extends the range of the species to some 150 km north of the Cold Bokkeveld and 50 km inland from the Gifberg. The record is surprising as *B. ambigua* does not, according to available records, occur in the Cedarberg, which lies between Botterkloof and the next nearest populations of the species to the south. This is the first record of *B. ambigua* from Northern Cape. The vegetation in the localized area of coarse sandy soil at the top of Botterkloof Pass is dominated by clumps of *Willdenowia* (Restionaceae) and includes several annual species of Scrophulariaceae. The otherwise largely coastal and lowland sandveld species, *Gladiolus speciosus* and *B. ringens* have also been found at this site, the latter a sight record supported by a photograph (Manning & Goldblatt 1997: 91).

Additional specimen

NORTHERN CAPE.—3119 (Calvinia): top of Botterkloof Pass, sandy ground, (–AD), 31 August 2006 (fruiting), *Goldblatt & Porter 12731* (MO, NBG).

NEW NAMES FOR *BABIANA LONGIFLORA* AND
B. THUNBERGII

After examining the draft checklist of Iridaceae at the Royal Botanic Gardens, Kew website, World Checklist of selected plants families (Govaerts pers. comm.), we have learned that the southwestern Cape species *Babiana longiflora* Goldblatt & J.C.Manning (2004) is a homo-

nym for *B. longiflora* (L.f.) Steud. We propose the new name *B. tubaeformis* for this rare plant. Also, there is a valid and legitimate earlier synonym, *Antholyza hirsuta* Lam. (1783), for *B. thunbergii* Ker Gawl. (1804), a common species of coastal sands of western South Africa. We provide a new combination *B. hirsuta* and present a more complete synonymy for this species than that given in our revision of the genus (Goldblatt & Manning 2007).

***Babiana tubaeformis* Goldblatt & J.C.Manning**, nom. nov., pro *B. longiflora* Goldblatt & J.C.Manning in Bothalia 34: 94 (2004), nom. illeg. non *B. longiflora* (L.f.) Steud.: 686 (1840) (= *Tritonia cooperi* subsp. *cooperi*).

***Babiana hirsuta* (Lam.) Goldblatt & J.C.Manning**, comb. nov.

Antholyza hirsuta Lam., Encyclopedie methodique, Botanique, vol. 1: 201 (1783). *Gladiolus sulcatus* Lam.: 119 (1791), nom. illeg. superfl. pro *A. hirsuta* Lam. *Gladiolus mollis* Vahl: 119 (1805), as a new name for *Antholyza hirsuta* Lam. Type: without locality or collector, 'antholyza hirsuta. encycl.' (Herb. Lamarck, P, holo!).

Babiana thunbergii Ker Gawl.: 233 (1804), as a new name for *Antholyza plicata* L.f.: 96 (1782). *Anacalanthe plicata* (L.f.) N.E.Br.: 269 (1932).

Anacalanthe namaquensis N.E.Br.: 269 (1932). *Antholyza namaquensis* (N.E.Br.) Goldblatt: 444 (1971).

NOMENCLATURE: WHO IS THE AUTHOR OF *BABIANA*?

The genus *Babiana* was formally described in August 1802 in *Curtis's Botanical Magazine* by John Gawler, now known to the botanical community as John Ker Gawler (Gawler subsequently changed his name to Bellenden Ker). The article that accompanied a painting of *Babiana plicata* Ker Gawl. (now *B. fragrans* (Jacq.) Steud.) included formal Latin and English descriptions of *Babiana* and the single species, *Babiana plicata* (itself a replacement name for *Gladiolus plicatus* Thunb. non L.). *Babiana plicata* is thus the type species of the genus. Ker Gawler (1802a) believed he was the author of this southern African genus, which now includes some 90 species (Goldblatt & Manning 2007), and so did contemporary and later authorities, notably Steudel (1840), Klatt (1882) and Baker (1877, 1892, 1896). Both Klatt and Baker were specialists in the systematics of Iridaceae. Lewis (1959), who revised *Babiana* almost 50 years ago, also treated the genus as having been described by Ker Gawler in August 1802.

Dandy (1969) proposed the conservation of *Babiana* against *Beverna* Adans. (1763) and the Committee for Spermatophyta (McVaugh 1971) recommended its conservation. *Babiana* thus appeared in the list of conserved generic names in the subsequent *International Code of Botanical Nomenclature* (Stafleu *et al.* 1972: 290) as *Babiana* Ker Gawl. (1802a). Then, in the list of conserved generic names in the Sydney Code (Voss *et al.* 1983: 330), the genus suddenly appears as *Babiana* Ker Gawl. ex Sims (1801).

The reason appears to be as follows. In an article in *Curtis's Botanical Magazine*, plate 539 (November 1801), Ker Gawler provided a formal account of the pre-

viously and validly published *Ixia conica* Salisb. This is followed by a short narrative about the Cape (i.e. western South African) species of Iridaceae written by Sims, the editor of the magazine and author of the article. After first discussing the history of *I. conica* and its possible synonyms, Sims proceeded to comment on the current state of the taxonomy of Jussieu's natural order [family] Irides (sic). Sims then related the difficulty of circumscribing genera in the family because of the conflicting patterns of variation in perianth tube length and shape and the symmetry of the flower (our paraphrasing). Sims continued: 'so that, notwithstanding the pains he has taken, our friend Mr. Gawler, has not been as yet able to reduce the genus [*Ixia*] to its proper standard, and is best able for the present only to divide it into several sections, distinguished from each other by characteristic marks, with notices of such as appear to him most likely to become the foundation of future separate genera. With these observations we hope soon to have an opportunity of treating our botanical readers'. [We note here that Ker Gawler subsequently described *Tritonia* (1802b), *Anomatheca* (1804) (now a synonym of the conserved *Freesia* Klatt), *Geissorhiza* (1804), and *Hesperantha* (1804), the last three genera in König & Sims's *Annals of Botany*, all based on species until then included in *Gladiolus* and *Ixia*.]

Continuing, Sims (1801) wrote: 'In the mean time, there is one division, the species composing which are at the present dispersed in the three genera of *Ixia*, *Gladiolus*, and *Antholyzai*, so very distinct at first sight from the rest, by their smooth sheathing petioles, terminated in general by a plicate and villous leaf, with their bulbs situated unusually deep in the earth, that Mr. Gawler has with the greatest propriety united these into a separate genus, with the name of *Babiana*'. Sims goes on to list the species that the genus 'will contain' [when it has been described and combinations made is evidently intended here] in the above three genera that belong in *Babiana*. Sims here clearly ascribed the genus name *Babiana* to Ker Gawler and provided a diagnosis that is clearly credited to the investigations of Ker Gawler ('so very distinct . . . that Mr. Gawler has . . .') and may be either a direct quote or a paraphrase. Thus, if this article is accepted as the valid place of publication, *Babiana* must be attributed to Ker Gawler alone under article 46.2 of the International Code of Botanical Nomenclature (McNeill *et al.* 2006). Foster (1979: 167) evidently accepted this interpretation by the listing of *Babiana* Ker Gawler (1801) in *Index Nominum Genericorum*.

In August 1802, just nine months after Sims's comments about the taxonomy of *Ixia*, Ker Gawler (1802a) formally described *Babiana* in *Curtis's Botanical Magazine*. There is no mention of the November 1801 article in which Sims informed the readers of the same magazine about the imminent publication of a new genus *Babiana*. Clearly neither Ker Gawler nor Sims considered the name to have been published, as implied by the phrase 'This genus will contain . . .' We thus argue that Sims (1801) merely mentioned *Babiana* in anticipation of its future acceptance and therefore did not validly publish it under Article 34.1(b) of the Code (McNeill *et al.* 2006).

Because "The Code does not provide for conservation of a name against . . . an 'isonym', the same name with the same type but with a different place and date of valid publication and perhaps with a different authorship . . . than is given in the relevant entry in App. II, III, or IV" (Art. 14.4 Note 1), we can and should change the citation of *Babiana* Ker Gawl. ex Sims (1801) in the Sydney Code and subsequent Codes to *Babiana* Ker Gawl. (1802).

ACKNOWLEDGEMENTS

Support for this study by grant 7799-05 from the National Geographic Society is gratefully acknowledged. Collecting permits were provided by the Nature Conservation authorities of Northern and Western Cape, South Africa. We thank Mrs A. Visser for permission to collect on her land and Lendon Porter for his assistance and companionship in the field. We acknowledge Bertil Nordenstam, Dan Nicolson, John McNeill, and Kanchi Gandhi for comments on the nomenclature of *Babiana*, the two last-named, not, however, in agreement with our conclusion.

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The genus *Wellstedia* (Boraginaceae: Wellstedioideae) in southern Africa

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Keywords: Boraginaceae, palynology, phytogeography, southern Africa, taxonomy, *Wellstedia* Balf.f., Wellstediaceae, Wellstedioideae

ABSTRACT

This regional taxonomic revision of the genus *Wellstedia* Balf.f., a member of the family Boraginaceae *s.l.* (including Hydrophyllaceae *s.str.*), is part of a series of publications on the Boraginaceae in southern Africa. *Wellstedia* comprises six species, five in Socotra, Somalia and Ethiopia with the remaining one, *W. dinteri* Pilg., occurring in southern Africa. *W. dinteri* Pilg. subsp. *dinteri* occurs in Namibia and the Northern Cape, whereas the newly instated subspecies *W. dinteri* subsp. *gracilior* (D.R.Hunt) Retief & A.E.van Wyk, based on *W. dinteri* Pilg. var. *gracilior* D.R.Hunt, is confined to Namibia only. The disjunct distribution of *Wellstedia* and numerous other plant and animal taxa between the arid regions of northeastern Africa and southern Africa is usually explained by the postulated periodic existence of an arid corridor between the two regions during the arid phases of the Pleistocene and even earlier. *Wellstedia* is treated here in Wellstedioideae, a subfamily of Boraginaceae *s.l.* but is sometimes placed in a family of its own, Wellstediaceae Pilger. Morphologically *Wellstedia* displays strong similarity to genera of the Ehretiaceae and also to certain members of the Hydrophyllaceae. The genus is characterized by a perennial, dwarf shrub habit, densely hairy leaves, 4-merous flowers, a terminal, bifid style and a 1- or 2-seeded capsule. A key to the two subspecies, diagnostic characters, a distribution map and illustrations of various macro- and micromorphological features are provided.

INTRODUCTION

Wellstedia was described in 1884 by Balfour after a visit to the island of Socotra. He decided on the name *Wellstedia* in honour of the British Lieutenant J.R. Wellsted, who explored Socotra for the Indian Government in 1834 (Thulin & Johansson 1996). Balfour believed that *W. socotrana* Balf.f., the only species in the genus at the time, had its closest affinity with members of Boraginaceae *s.str.* Besides this species, five more are now recognized on the African continent—four in Somalia and Ethiopia, and one in Namibia and South Africa. Such floristic (and faunistic) disjunctions between the arid regions of northeastern Africa and southern Africa are usually ascribed to the periodic existence of a linking arid corridor between the two regions in the past (Van Wyk & Smith 2001). In 1912 Pilger placed *Wellstedia* in its own subfamily, Wellstedioideae (Boraginaceae). Novák (1943), however, decided on a separate family, Wellstediaceae. Since then, the family classification of *Wellstedia* has been a matter of controversy. Merxmüller (1960), unaware of Novák, also established a new family, Wellstediaceae, thereby creating a later homonym. In 1967 the family was also recognized by Friedrich-Holzhammer in a *Prodromus* on the flora of South West Africa [Namibia], an approach more recently followed by Lebrun & Stork (1997).

Different modern views regarding the delimitation of Boraginaceae exist: splitting Boraginaceae *s.l.* into two separate families, Boraginaceae *s. str.* and Heliotropiaceae with Hydrophyllaceae not included (Diane *et al.* 2002); or recognizing several segregate families, Boraginaceae

s. str., Cordiaceae, Ehretiaceae, Heliotropiaceae, Hydrophyllaceae, Lennoaceae and Wellstediaceae (Lebrun & Stork 1997; Gottschling *et al.* 2001; Gottschling 2003). In the present contribution, *Wellstedia* is regarded as a monotypic genus of the subfamily Wellstedioideae within Boraginaceae *s.l.* (including Hydrophyllaceae *s.str.*, Codonoideae, Ehretiaceae, Heliotropioideae and Boraginoideae) (Retief 2003). Ferguson (1999) and the Angiosperm Phylogeny Group II (2003) are followed here in regarding the tribes Phacelieae and Hydrophyllaeae as part of Boraginaceae *s.l.* The capsular fruit of *Wellstedia* is unknown elsewhere in Boraginaceae *s.str.* and has been used to motivate the recognition of a monotypic family Wellstediaceae. However, with members of Hydrophyllaceae, all with capsular fruits, included in a broadly defined Boraginaceae, this argument is no longer of importance. Pollen and other characters such as a terminal style, 4-merous flowers, trichomes with multicellular bases and cymose inflorescences similar to other traditional members of Boraginaceae, support the placement of *Wellstedia* in a subfamily within Boraginaceae *s.l.*

The aim of this paper is to present a taxonomic revision of the genus *Wellstedia* in southern Africa, including Namibia, Botswana, South Africa, Lesotho and Swaziland. Diagnostic characters, an identification key, illustrations and a distribution map are provided. This paper forms part of a revision of the Boraginaceae in southern Africa. The genus description is based on material from southern Africa only.

MATERIALS AND METHODS

Herbarium specimens in BM, BOL, E, GRA, K, NBG, NH, NU, PRE, PRU, SAM and WIND (acronyms as in Holmgren *et al.* 1981) were studied to gather data on morphological characters, phenology and geographical distribution. Pollen and various plant parts were studied with an ISI-SX-25 scanning electron microscope. Measurements of pollen grains were done from aceto-

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lysed grains mounted in glycerine jelly. Acetolysis followed the standard method of Erdtman (1960). Tapetal orbicules were obtained from herbarium specimens and prepared for viewing with a JEOL 6000 F in-lens field emission scanning electron microscope (for procedure followed see Retief *et al.* 2001, 2002).

HISTORICAL OUTLINE

In 1912, Pilger described *W. dinteri* from specimens collected by botanist and botanical explorer Moritz Kurt Dinter (1868–1945) in Namibia. Although Pilger knew the genus only from Balfour's (1884) description and illustration of *W. socotrana*, he was convinced that Dinter had found a *Wellstedtia* in the southwestern part of Africa. He was also of the opinion that *Wellstedtia* belongs to Boraginaceae with affinity to *Coldenia* L. of the Ehretioideae, and not Verbenaceae, a family also mentioned by Balfour (1884) when he described the first species. The capsular fruit with two seeds, however, distinguishes *Wellstedtia* from all other members of Boraginaceae and a new subfamily Wellstedioideae was described by Pilger (1912).

Hunt (1969) divided *W. dinteri* into two varieties. Variety *dinteri* is characterized by flowers and capsules congested on short lateral branches, whereas var. *gracilior* has flowers and capsules on lax branchlets, appearing as if solitary, axillary, rarely close together. When Friedrich-Holzheimer (1967) revised the genus for *Prodromus einer Flora von Südwestafrika*, she did not recognize the two infraspecific taxa proposed by Hunt (1969) and regarded *W. dinteri* as belonging to Wellstediaceae. Thulin & Johansson (1996), in a revision of the genus, also did not maintain the two varieties in *W. dinteri*. They classify the genus in Wellstedioideae and proposed the New World genus *Tiquilia* Pers. (Boraginaceae: Ehretioideae) as a possible sister to it. In the present revision, the status of *W. dinteri* Pilg. var. *gracilior* D.R.Hunt is raised to that of subspecies, a decision based mainly on differences in macromorphology and habitat.

PHYTOGEOGRAPHY

The two subspecies of *Wellstedtia dinteri* in southern Africa (Figure 1) are associated with the Nama-Karoo, Succulent Karoo and Savanna Biomes, according to the biome map in Van Wyk & Smith (2001: 8). *W. dinteri* subsp. *dinteri* is recorded as growing in shale-derived soil mixed with fine gravel (Davidse & Loxton 6339). *W. dinteri* subsp. *gracilior*, however, occurs on dolomite or limestone (Acocks 15641) or on black soil derived from dolomite.

Arid regions of the African continent are phytogeographically linked by a large number of taxa with disjunct distributions. This pattern is particularly well developed between arid regions in southern Africa and northeastern Africa (Horn of Africa and adjacent Arabian Peninsula). *Wellstedtia* is a typical example of a taxon with a disjunct distribution between the arid areas of northeastern Africa and southern Africa: *W. din-*

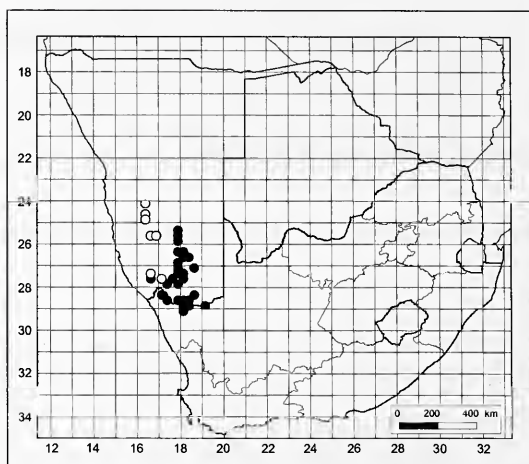


FIGURE 1.—Known distribution of *Wellstedtia dinteri* subsp. *dinteri*, ●, and *W. dinteri* subsp. *gracilior*, ○.

teri occurring in Namibia and Northern Cape (Figure 1), whereas *W. filtuensis* Hunt & Lebrun is endemic to Ethiopia, with *W. somalensis* Thulin & A.Johansson, *W. robusta* Thulin and *W. laciniata* Thulin & A.Johansson, confined to Somalia. The disjunct pattern is usually explained by the postulation of an arid corridor (or corridors) linking these regions during arid phases of the Pleistocene and even earlier (Verdcourt 1969; Goldblatt 1978; Van Wyk & Smith 2001). Various other authors, for example, De Winter (1971), Thulin (1994) and Thulin & Johansson (1996) also commented on the recurring pattern of disjunct distributions. *Gaillonia* A.Rich. ex DC. (Rubiaceae), as circumscribed by Thulin (1998), is another example of a genus with a disjunct distribution comparable to that of *Wellstedtia* (Thulin 1994).

Disjunct distributions in Africa and the New World are rather unusual, but for southern Africa, as many as seven families and many more genera are involved (Goldblatt 1978). *Codon* L., an exclusively southern African genus, has its nearest relatives, members of Hydrophyllaceae *s.str.*, in North America. However, *Wellstedtia* also shows similarities in pollen and habit characters with some of the genera of Hydrophyllaceae *s.str.* A possible explanation for this disjunct distribution pattern is the existence of a Tertiary North Atlantic land bridge (Tiffney 1985), whereas over-water dispersal seems unlikely, except during the early stages of continental separation.

CHARACTERS OF TAXONOMIC SIGNIFICANCE

Habit

Members of the Boraginaceae are mainly herbaceous, but shrubs and trees do occur. *Wellstedtia* is characterized by a woody, dwarf shrub habit, a growth form also displayed by *Tiquilia*, of the subfamily Ehretioideae—suggested as a potential sister group of *Wellstedtia* (Thulin & Johansson 1996). The woody habit and other morphological similarities with the Ehretioideae support the classification of *Wellstedtia* as a member of the Boraginaceae *s.l.* instead of placing it in a family of its own.

Leaves

The narrowly obovate to ovate leaves of the southern African species with its two subspecies are densely pubescent (Figure 2A, B). The trichome complement consists of

rigid setae with multicellular bases, usually 3-layered, scattered on the blade (Figure 2C) and fine setae with undeveloped bases. Leaves of *Wellstedia dinteri* subsp. *gracilior* are smaller in size and different in colour, greyish white compared to yellowish green in *W. dinteri* subsp. *dinteri*.

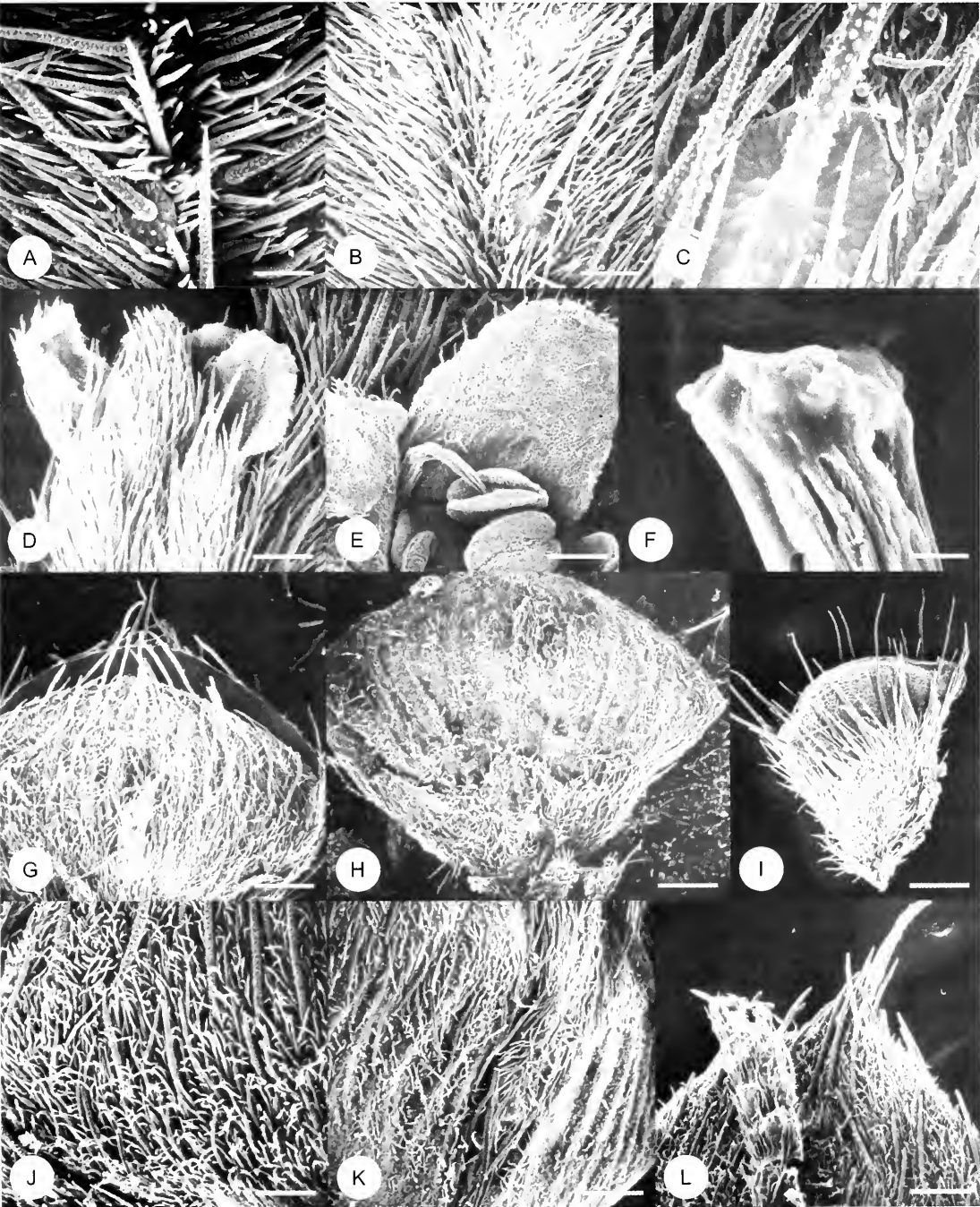


FIGURE 2.—Morphology of *Wellstedia*. A–C, leaf: A, *W. dinteri* subsp. *dinteri*, Acocks 15615, upper leaf surface; B, *W. dinteri* subsp. *gracilior*, Müller 1329, upper leaf surface; C, *W. dinteri* subsp. *dinteri*, Liebenberg 5179, multicellular base of a seta. D–F, flower: D, *W. dinteri* subsp. *gracilior*, Müller 1329, calyx and corolla; E, *W. dinteri* subsp. *dinteri*, Leistner 2589, anthers; F, *W. dinteri* subsp. *dinteri*, Oliver & Müller 6397, stigma and style. G–K, fruit: *W. dinteri* subsp. *dinteri*, Oliver & Müller 6397: G, capsule splitting open; I, seed; J, indumentum of capsule. *W. dinteri* subsp. *gracilior*, Müller 1329: H, capsule; K, indumentum of capsule. L, *W. dinteri* subsp. *dinteri*, Oliver & Müller 6397, part of capsule and calyx lobe. Scale bars: A, 75 µm; B, 259 µm; C, 89 µm; D, 365 µm; E, 24 µm; F, 16 µm; G, 460 µm; H, 431 µm; I, 314 µm; J, 259 µm; K, 254 µm; L, 509 µm.

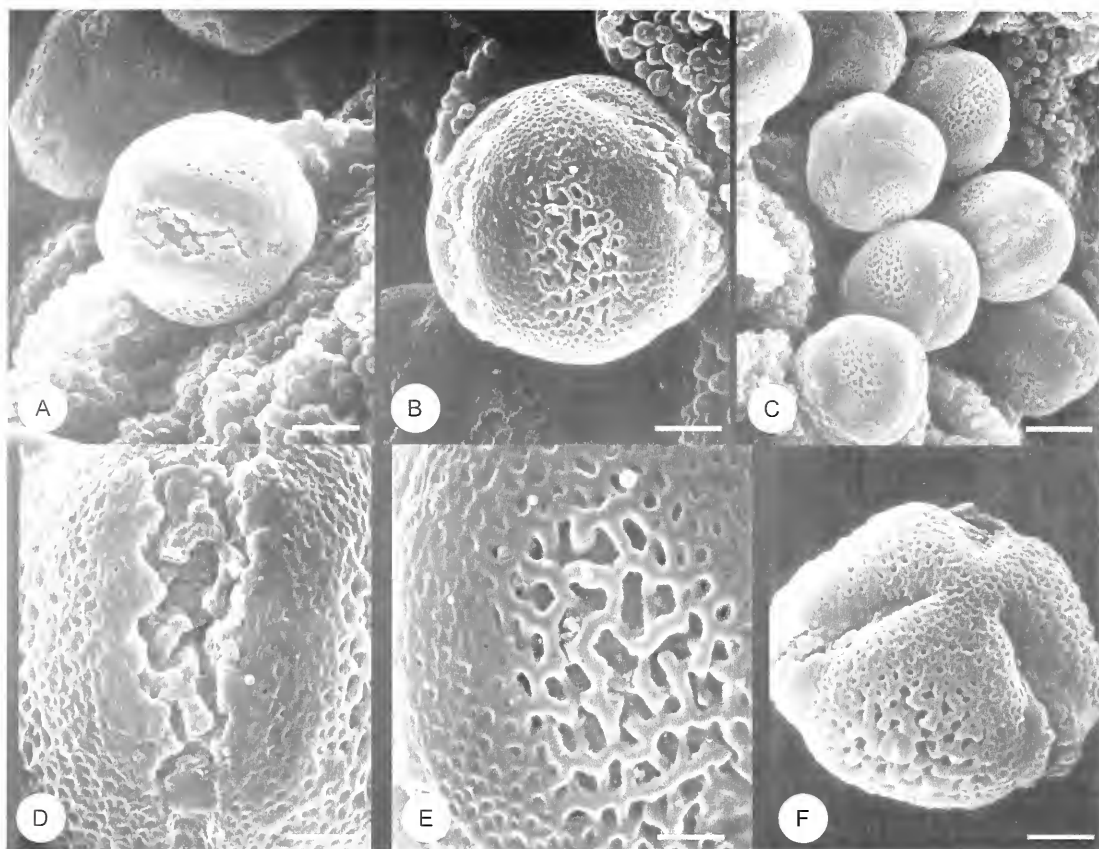


FIGURE 3.—Pollen morphology of *Wellstedtia dinteri* subsp. *dinteri*. A–E, *Leistner 2589*: A, pollen grain in equatorial view, tapetum clothed with orbicules; B, grain showing mesocolpial concavity; C, grains in different views; D, compound aperture; E, mesocolpial concavity, tectum reticulate. F, *Oliver & Müller 6397*, grain ± in polar view. Scale bars: A, 4 μ m; B, 2.9 μ m; C, 23 μ m; D, 2.1 μ m; E, 1.2 μ m; F, 2.5 μ m.

Flowers

Flowers of *Wellstedtia* are 4-merous (Figure 2D), a state which is rare in Boraginaceae *s.l.* It is often used to support the recognition of a separate family, Wellstedtiaceae. However, the flowers of *Coldenia*, a monotypic genus and also a member of the Ehretioideae, is similarly 4-merous. This is another link between *Wellstedtia* and a member of Boraginaceae *s.l.* The calyx is deeply lobed and accrescent in fruit (Figure 2L). The outer surface of the corolla is densely pubescent (Figure 2D), but the inner surface is glabrous (Figure 2E). A terminal style is present (Figure 2F), persistent (Figure 2L) and slightly bifid with capitate stigmas, the latter covered with exudate when receptive (Figure 2F).

Fruit and seed

All members of *Wellstedtia* are characterized by hairy, mussel-like capsules (Figure 2G, H, J, K), but differ in dissepiment morphology (Thulin & Johansson 1996). The seeds (Figure 2I) are truncate, and pitted above with a circle of long, rigid trichomes in the upper part.

Pollen

Pollen grains (Figure 3A–F) of *Wellstedtia* are tricolporate, isopolar and with mesocolpial concavities (some-

times regarded as ‘pseudocolpi’) and a reticulate tectum, showing strong similarity with genera of the subfamily Ehretioideae (Retief & Van Wyk 2001). *Wellstedtia* and members of Ehretioideae furthermore show similarity in their pollen morphology with members of the tribes Hydrophyllae and Phacelieae of the family Hydrophyllaceae, here regarded as part of Boraginaceae *s.l.* Doughnut-shaped tapetal orbicules (Retief *et al.* 2001: fig. 2), occur in both *Wellstedtia* and *Codon*, confirming the close relationship of these genera.

TAXONOMIC TREATMENT

***Wellstedtia* Balf.f.** in Proceedings of the Royal Society of Edinburgh 12: 402 (1884); Gürke: 131 (1897); Pilg.: 558 (1912); E.Phillips: 633 (1951); Friedr.-Holzh.: 121 (1967) as Wellstedtiaceae; D.R.Hunt: t. 3665, 3666 (1969); R.A.Dyer: 514 (1975); Thulin & Johansson: 80 (1996); Retief: 183 (2000). Type: *W. socotrana* Balf.f.

Dwarf shrubs, densely pubescent with trichomes appressed; trichome complement consists of rigid setae with prominent multicellular bases or fine setae with undeveloped bascs. Branches decumbent or ascending. Leaves spirally arranged; blade narrowly obovate to spatulate, decurrent, often upper part (‘blade’) forms an

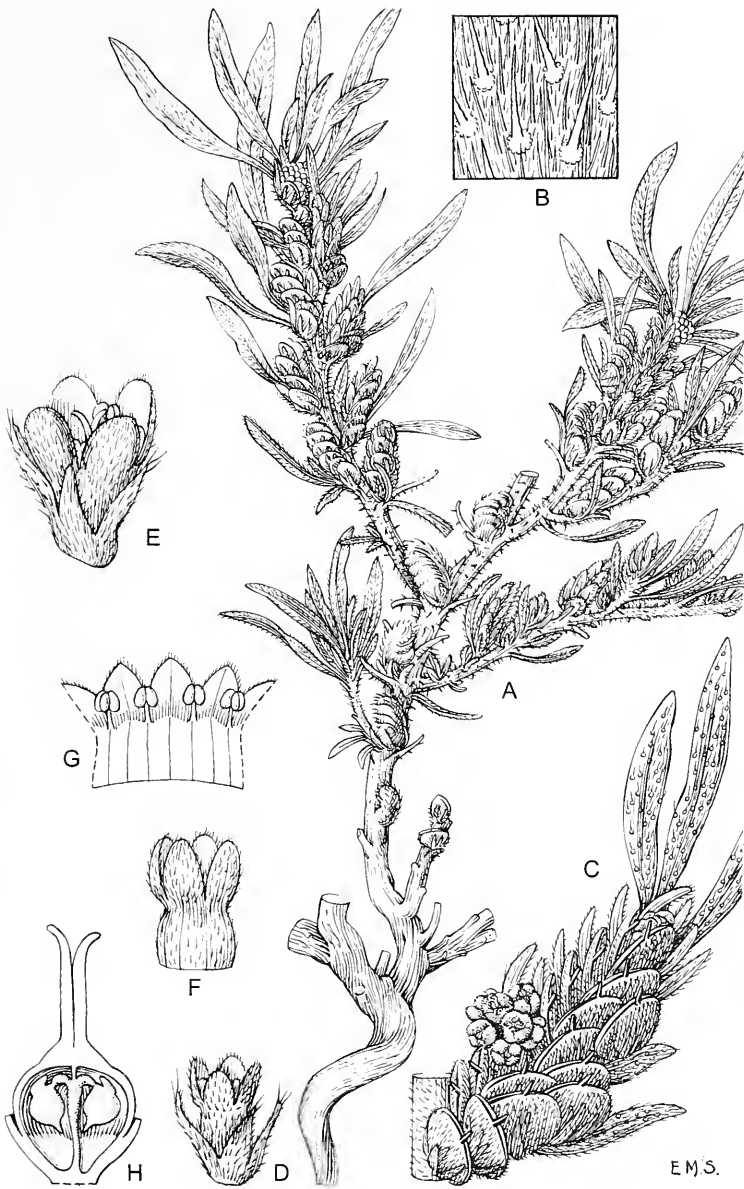


FIGURE 4.—*Wellstedtia dinteri* subsp. *dinteri* (= *W. dinteri* var. *dinteri*), Acocks 18101. A, habit, $\times 1$; B, part of lower leaf surface, $\times 6$; C, branchlets with flowers and fruits, $\times 3$; D, flower, $\times 8$; E, flower, $\times 12$; F, corolla, $\times 12$; G, corolla opened out, $\times 12$; H, placentation and developing seeds (semi-diagrammatic), $\times 24$. Artist: E.M. Stones, with kind permission; taken from Hunt (1969).

abscission, with lower part ('petiole) persistent, becoming spine-like. *Flowers* small, regular, in dense, scorpioid cymes or solitary, well separated on lax branches. *Calyx* deeply 4-lobed. *Corolla* pink or white, with a short, campanulate tube, slightly constricted at throat. membranous with 4 ovate lobes \pm as long as tube or shorter. *Stamens* 4, borne on corolla throat, shorter than corolla lobes; filaments linear, exserted; anthers subglobose, \pm as long as filaments, 2-locular, dehiscing introrsely. *Disc* absent. *Ovary* bilocular, compressed, densely hairy, with a single ovule in each loculus; style terminal, bifid at apex; stigmas small, capitate. *Fruit* a capsule, variously pubescent, loculicidally dehiscent. *Seeds* \pm triangular, truncate and pitted above with a circle of long, rigid trichomes in upper part below pitted area, acute and shortly pubescent below.

Key to subspecies

- Flowers and capsules congested on short, lateral branchlets; leaves yellowish green, $10\text{--}50 \times 3.5\text{--}6.0$ mm; leaf blade surface with multicellular-based setae prominent and an under layer of fine setae with undeveloped bases 1. *W. dinteri* subsp. *dinteri*
- Flowers and capsules well spaced on lax branchlets; leaves greyish white, $7\text{--}15 \times 2.0\text{--}4.5$ mm; leaf blade surface densely pubescent, with fine setae with undeveloped bases and scattered setae with multicellular bases 2. *W. dinteri* subsp. *gracilior*

1. *Wellstedtia dinteri* Pilg. subsp. *dinteri* in Botanische Jahrbücher 46: 559 (1912); Friedr.-Holzh.: 1 (1967) pro parte; D.R.Hunt: 4 (1969). Syntypes: Namibia, Karasberge, Sandverhaar, *Dinter* 1193 (B \dagger); Namib, *Dinter* 1379 (B \dagger); Auchab, *Range* 691 (B \dagger ; SAM!); Karibis, *Dinter* 1250 (B \dagger ; SAM!, lectotype, designated here).

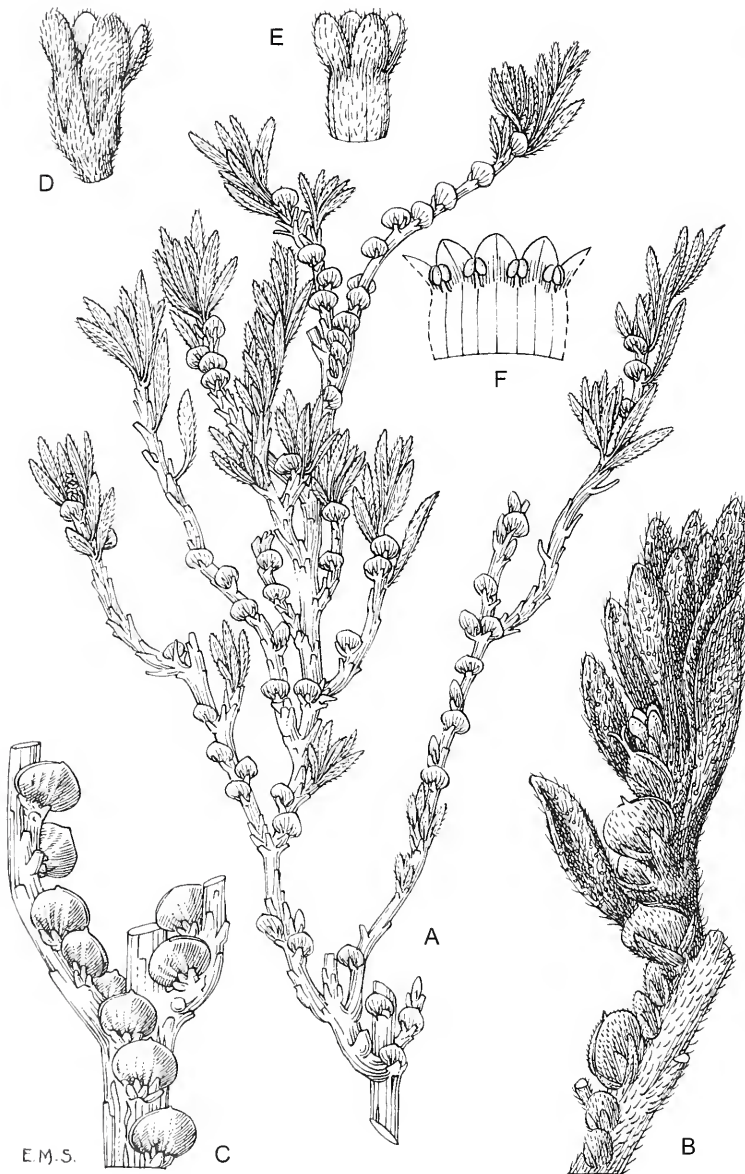


FIGURE 5.—*Wellstedia dinteri* subsp. *gracilior* (= *W. dinteri* var. *gracilior*), Strey 2140. A, habit, $\times 1$; B, branchlet with flowers and fruit, $\times 3$; C, older branchlet with fruit, $\times 3$; D, flower, $\times 10$; E, corolla, $\times 10$; F, corolla opened out, $\times 10$. Artist: E.M. Stones, with kind permission; taken from Hunt (1969).

Illustration: Hunt: t. 3666 (1969). Figure 4.

Dwarf shrub, up to 300 mm high, with pseudodichotomous branching. *Stems* procumbent, decumbent or ascending. *Leaves* yellowish green, $10\text{--}50 \times 3.5\text{--}6.0$ mm; leaf blade with multicellular-based setae, distinctly spaced, and an under layer of fine trichomes prominent. *Corolla* pink, white or pale rose in centre, white along margins; tube ± 1 mm long. *Flowering time*: April to May, August to October.

Distinguishing characters: dwarf shrub; leaves $10\text{--}50 \times 3.5\text{--}6.0$ mm; flowers and capsules mostly congested on short, lateral branchlets; leaf blade with multicellular-based setae, setae distinctly spaced, and an under layer of fine trichomes prominent.

Distribution and habitat: *Wellstedia dinteri* subsp. *dinteri* is found in Namibia and Northern Cape (Figure 1). It occurs on arid, gravelly hillocks, in shallow soil between rocks and stones.

2. *Wellstedia dinteri* subsp. *gracilior* (D.R.Hunt) Retief & A.E. van Wyk, comb. et stat. nov.

W. dinteri Pilg. var. *gracilior* D.R.Hunt in Hooker's *Icones Plantarum* 37: t. 3667 (1969). Type: Namibia, Buellspoor, Strey 2140 (K!, holo.; BOL!, PRE!, WIND!).

Illustration: Hunt: t. 3667 (1969).

Procumbent, dwarf shrub with branches radiating from centre, $\pm 100\text{--}150$ mm high, 300–400 mm diam. *Leaves* greyish white, $7\text{--}15 \times 2\text{--}4.5$ mm; leaf blade surface densely pubescent with fine setae, bases unde-

veloped, and scattered setae with multicellular bases. Corolla white; tube \pm 1.5 mm long. Flowering time: August to February. Figure 5.

Distinguishing characters: procumbent, dwarf shrub; leaves 7–15 \times 2.0–4.5 mm; flowers and capsules mostly solitary on lax branchlets; leaf blade surface densely pubescent, with fine setae, bases undeveloped, and scattered setae with multicellular bases.

Distribution and habitat: *Wellstedtia dinteri* subsp. *gracilior* is found in Namibia (Figure 1). It occurs on rocky hillsides, black rocks and broken veld on dolomite.

SPECIMENS EXAMINED

The numbers in brackets signify the identity of the specimens: (1) *W. dinteri* subsp. *dinteri*; (2) *W. dinteri* subsp. *gracilior*.

Acocks 15615 (1) PRE; 15641 (2) PRE; 18101 (1) K, PRE, WIND.

Bean, Vlok & Viviers 1817 (1) BOL.

Craven 2532, 2597 (1) WIND.

Davide 6339 (1) PRE, *De Winter* 3270 (1) K, PRE, WIND. *Dinter* 1250 (1) SAM; 4845 (1) BOL, K, PRE, SAM.

Galpin 14163 (1) E, PRE. *Giess* 14521 (1) WIND. *Giess & Müller* 12165 (1) PRE, WIND; 14324 (1) WIND. *Giess, Volk & Bleissner* 5324 (2) K, PRE, WIND; 6829, 6978 (1) PRE, WIND; 8763 (1) PRE. *Goldblatt & Manning* 8856 (1) PRE, WIND; 8763 (1) PRE. *Günster* 9366 (2) WIND.

Kubirske & Coetzee 98 (1) WIND.

Jürgens 22412 (1) PRU; 22710 (1) PRE.

Leistner 2589 (1) PRE, WIND. *Liebenberg* 5179 (1) K, PRE, WIND; 5179 A (1) PRE.

Merxmüller & Giess 3444 (2) K, PRE, WIND; 3642 (1) K, PRE, WIND. *Müller* 265 (1) PRE, PRU, WIND; 1329 (2) PRE, WIND; WIND26709 (1) WIND.

Oliver & Müller 6397 (2) K, PRE. *Oliver, Muller & Steenkamp* 6322 (1) K, PRE.

Pearson 4669 (1) BOL, GRA, SAM; 8576 (1) K, BOL, PRE.

Range 691 (1) SAM. *Rodin* 2843 (1) BOL, K, PRE.

Schlieben 9084 (1) BM, K, NBG, PRE. *Strey* 2140 (2) K, PRE, WIND. *Strohbach, Kubirske & Sheuyange* 3011 (1) WIND. *Smook* 7562 (2) PRE. *Strohbach & Chivell* 3474 (1) WIND.

Thompson & Le Roux 206 (1) NBG.

Van Jaarsveld, Forester & Jacobs 8428 (2) NBG. *Van Wyk* 8709 (1) PRE, PRU, WIND. *Volk* 12277 (1) WIND.

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Notes on African plants

VARIOUS AUTHORS

ASTERACEAE–GNAPHALIEAE

METALASIA HELMEI, A NEW MEMBER OF A SMALL CLADE FROM THE WESTERN CAPE?

The genus *Metalasia* R.Br. of the Asteraceae, tribe Gnaphalieae, was revised by Karis (1989). At that stage, 52 species and three subspecific taxa were recognized. An unknown *Metalasia* was recently collected by the second author on the Kwadousberg to the east of Worcester, in the Western Cape. After thorough investigation, it turned out that this newly collected plant does not fit into any currently known species of *Metalasia*, and that it constitutes a distinct, undescribed species.

Metalasia helmei P.O.Karis, sp. nov.

Fruticulus sine brachyblastis axillaribus. *Folia* basi plerumque \pm applanata versus apicem canaliculata, non tortilia, 3.2–6.5 mm longa. *Synflorescentiae* (4–)8–18 mm latae, densae, capitulis (2–)10–25. *Capitula* floribus 5. *Bracteae* involucri \pm 15, 6- vel 7-seriatae, intrinsecus gradatim longiores, erectae autem intimae erecto-patentes, extimae foliaceae vel subfoliaceae, intrinsecus scariosae vel petaloideae, brunneae vel atrobrunneae, intimae albae. *Cypselae* anguste oblongae vel anguste ovoideae, 2.2–3.0 mm longae, glabrae, costis 5–10 inaequaliter distributis. *Pappi* setae serratae, apicaliter clavatae.

TYPE.—Western Cape, 3319 (Worcester): Worcester Div., Kwadousberg, Farm Witvlakte 175, on plateau at head of Keurboskloof, 1 400 m, S 33°31' E 19°43', (–DA), 10-10-2005, *Helme* 3647 (NBG, holo.!; BOL!, K!, MO!, PRE!, S!).

Sparsely to well-branched shrublet up to 0.4 m high. *Branches* mostly erect, sometimes ascending, without brachyblasts, young whitish tomentose, older becoming less tomentose and with leaf scars; foliage on young shoots dense to very dense, but becoming less so with age. *Leaves* involute-erectoid, not twisted, very narrowly triangular to narrowly triangular or ovate-acuminate, upper part 3.2–6.5 \times 0.75–1.0, base 1.0–1.9 mm, acute or rounded apically, mucronate, tips straight or sometimes declinate, glabrous beneath, erect-spreading or rarely spreading, straight or occasionally subsquarrose, or slightly curved, often slightly involute and \pm flat at base and more involute and canaliculate towards tip. *Synflorescences* (4–)8–18 mm wide, campanulate, dense, with (2–)10–25 capitula arranged in obscure clusters or sometimes solitary. *Capitula* 5-flowered, sessile, free from one another. *Involucre* hairy for $\frac{3}{5}$ – $\frac{2}{3}$, cyathiform but conspicuously widened at petaloid part, apically 2.3–3.6 mm wide, slightly wider at anthesis; bracts \pm 15 in 6 or 7 series, gradually longer inwards, hyaline margins often absent or sometimes narrow or obsolete, outermost-inner erect, innermost erect-spreading; outermost

\pm half as long as innermost and foliaceous to subfoliaceous, narrowly ovate or elliptic, acute, mucronate; outer scarious, brown to dark brown (sometimes reddish), elliptic to narrowly elliptic to narrowly oblanceolate, acute to obtuse, mucronate or not; inner scarious to subpetaloid, brownish to whitish, oblanceolate or narrowly oblong, obtuse; innermost petaloid, white, narrowly oblanceolate, with folded and/or plicate apical margins. *Corolla* narrowly cylindrical, 3–4 mm long, purple or reddish above. *Cypselae* narrowly oblong to narrowly ovoid, 2.2–3.0 mm long, with \pm 5–10 unevenly distributed ribs, brown, glabrous. *Pappus* bristles slightly serrate, apically clavate. *Flowering time*: August–October. Figure 1.

Diagnostic characters: *Metalasia helmei* is a small shrublet immediately recognized by its mostly erect-spreading, untwisted and rather short leaves, by the 5-flowered capitula, and the dark brown, scarious, erect, outer involucral bracts which contrast with the innermost white ones which are erect-spreading. Furthermore, the fruits have 5–10 unevenly distributed ribs, and the pappus bristles are apically clavate. *M. helmei* is similar to many other small, shrubby *Metalasia* species in habit, but in its foliage it is most similar to *M. agathosmoides* Pillans which also has 5-flowered capitula, but the latter differs by its axillary brachyblasts, and the apically concave, pink, petaloid, involucral bracts.

DISCUSSION

Karis (1989) made a morphologically-based cladistic analysis of *Metalasia*, and *M. agathosmoides* formed a clade with *M. fastigiata* (Thunb.) D.Don on account of, among other things, the nonhomoplasious feature 'cypselas with 5–7 endocarpous ribs'. Regrettably, this description is erroneous since the reinforced cells of the fruit, constituting the ribs, are formed by the seed coat and not by the innermost layer of the carpels. However, it is obvious that *M. helmei* shares these fruit features with *M. agathosmoides* and *M. fastigiata*, but it shares the unusual foliage (Figure 1) with the former alone. Consequently, it is highly probable that *Metalasia helmei* and *M. agathosmoides* are sister species. There is a slight disjunction between *M. helmei* and the more widely distributed *M. agathosmoides* which has its closest locality at the Bonteberg, some 20–25 km to the northeast (Figure 2). As can be seen from the map, the disjunctions between the (known) populations of *M. agathosmoides* are more pronounced than between the species. Karis (1989, data from the herbarium sheets) reported a range in altitude

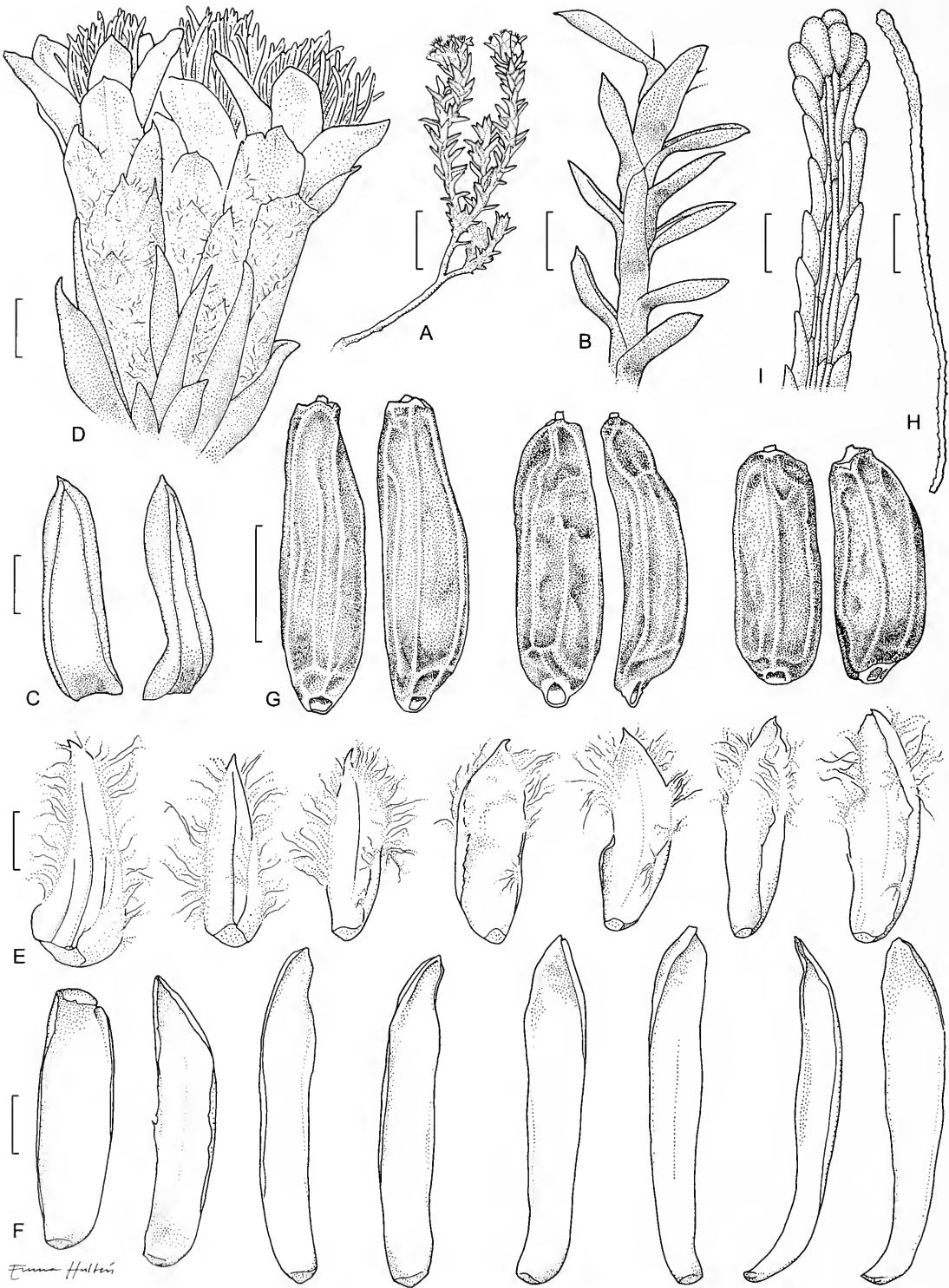


FIGURE 1.—*Metalsia helmei*, Helme 3138 (S). A, portion of plant; B, branch with leaves; C, leaf from above (left) and from side (right); D, capitula; E, F: all involucre bracts from one capitulum, with E, outermost from upper left, to innermost F, on lower right; G, three cypselae, each displayed from the ventral (left) and lateral (right) sides (note ribs). H, I, pappus; H, bristle; I, tip magnified. Scale bars: A, 10 mm; B, 2 mm; C–G, 1 mm; H, 0.5 mm; I, 0.1 mm. Artist: Emma Hultén.

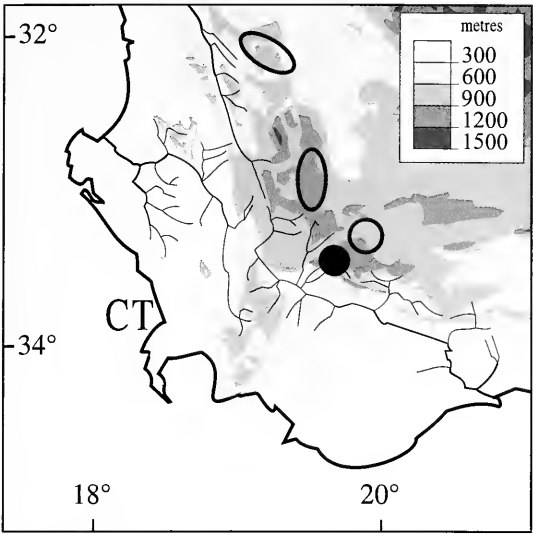


FIGURE 2.—Known distribution of *Metalasia helmei*, ●, and *M. agathosmoides*, ○, 0 (data from Karis 1989).

for *M. agathosmoides* of 1 250–1 700 m, but Karis subsequently collected material of this species at 900–950 m in the Cedarberg. *M. fastigiata* is also 5-flowered, as in *M. helmei* and *M. agathosmoides*, but differs from both those species by its larger size, by the twisted, rather sharp-pointed leaves, as well as the synflorescences with more numerous capitula. *M. fastigiata* also displays a much wider ecological range. A study based on molecular and morphological data (Stångberg & Karis in prep.) might indicate whether the *M. agathosmoides-fastigiata* clade now should be extended to contain also *M. helmei*, and, if the latter is sister to *M. agathosmoides*. If so, the high altitudinal range might be due to common ancestry. *Metalasia compacta* Zeyh. ex Sch.Bip. has leaves that approach those of *M. helmei*, i.e. with a ± flat and slightly involute base, but more conspicuously involute towards the tip. However, *M. compacta* differs by its robust habit, its pure white-tomentose younger branches, its twisted leaves, as well as its 6-flowered capitula that are arranged in larger synflorescences.

Distribution and habitat: *Metalasia helmei* is known only from the Kwadousberg, where it is fairly common in Sandstone Fynbos on well-drained, deep, coarse white sands from 1 400–1 800 m (Figure 2). The upper parts of this 12 km² range receive a light dusting of snow on average twice every winter. The area is relatively arid, and rainfall probably ranges for 400–700 mm per annum. The habitat is not under any direct threat, although there are old agricultural lands near the type locality, and there are estimated to be more than 10 000 plants. The entire known range of this nonresprouting species constitutes a single locality. Due to having less than five localities and occupying an area of less than 5000 km², it qualifies for Rare in terms of the Orange List criteria (Victor & Keith 2004).

Additional material examined

Western Cape.—3319 (Worcester): Worcester Div., Kwadousberg, Blaaskloof 182, summit ridge near jeep track, 1 700 m, (–DA), 24 Oct. 2004, *Helme* 3138 (NBG!, S).

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ASPHODELACEAE: ALOOIDEAE

BULBINE TRIEBNERI, AN EARLIER NAME FOR *BULBINE ALBA*, AS WELL AS ADDITIONAL AND NEW LOCALITIES IN EASTERN AND NORTHERN CAPE, SOUTH AFRICA

The genus *Bulbine* Wolf comprises ± 73 species occurring in Africa and Australia. While only six species are found in Australia (Watson 1987; Keighery 2004), 67 occur in southern Africa, with only five of these also extending into tropical Africa (Williamson 2003; Klopper *et al.* 2006). The genus is therefore essentially a southern African entity. *Bulbine* is characterized by miniature to low succulent plants with lax or dense racemes (sometimes somewhat corymbose) of mostly yellow (rarely white, orange or pink) flowers with bearded filaments

(Smith & Meyer 2000). *Bulbine triebneri* Dinter is the only known member of the genus with white flowers.

Following an earlier treatment of the genus *Bulbine* (Bajnath 1977), three white-flowered species with other distinguishing features were segregated into a new genus, *Jodrellia* Bajnath (Bajnath 1978). Although *B. triebneri* shares the character of white flowers with *Jodrellia*, it is a true *Bulbine*, sharing a close affinity with the other frutescent species. It is distinguished from its nearest

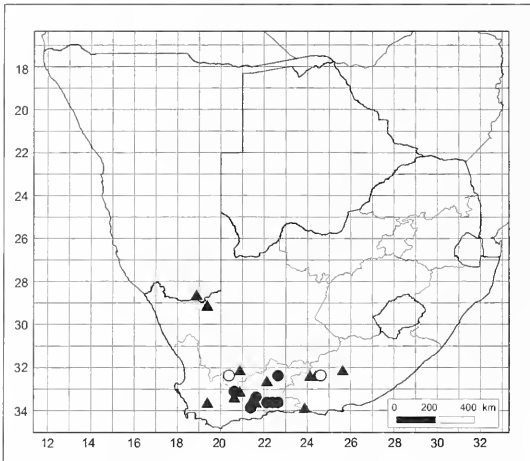


FIGURE 3.—Distribution of *Bulbine triebneri*, based on specimens at PRE, NGB and BOL, ●; specimens listed in Baijnath (1977), ▲; new localities in the Eastern and Northern Cape, ○.

relative *B. frutescens* (L.) Willd. by its soft-textured and glaucous, subterete leaves (Van Jaarsveld 2001).

Recently, Van Jaarsveld (2001) described a new species, *Bulbine alba* Van Jaarsv. from the Western Cape. Examination of the type material of *B. triebneri* and *B. alba* showed them to be conspecific, therefore *B. alba* becomes a synonym of *B. triebneri*. *B. triebneri* was based on Dinter 7899 (B, holo! –K, photo!), material that was collected by Von Triebner at Eendoom, east of Warmbad in Namibia and cultivated in Windhoek (Von Poellnitz 1943).

Bulbine triebneri is said to be widely distributed in the Little Karoo and southern Great Karoo (Van Jaarsveld 2001). The current known distribution, based on that of the synonym *B. alba*, is restricted to the Western Cape, from Laingsburg in the west to Oudtshoorn and Beaufort West in the east (Figure 3). It is locally abundant and grows on shale ridges and scree in the Succulent Karoo and along the southern border of the Nama-Karoo (Van Jaarsveld 2001). Baijnath (1977) has shown this taxon to have a much wider distribution in the Western and Eastern Cape and that it also extends into the Northern Cape Province.

A healthy population of *Bulbine triebneri* was recently found in natural vegetation in the Urquhart Caravan Park, Graaff-Reinet, Eastern Cape. At this locality, the plants grow in full sun on a south-facing scree slope next to the road leading to the bottom of the wall of the Van Ryneveld's Pass Dam. According to the management of the park, this area has never been under cultivation and it is therefore a natural occurrence of the species. The area falls in the Southern Karoo Riviere vegetation type (Mucina & Rutherford 2006). The plants, with their pale bluish green leaves, were well camouflaged among the grass and other vegetation of the slope while their flowers were closed early in the day, and only a few plants right next to the road were initially noticed. Upon returning to the site in the late afternoon, it was found that the flowers had opened and that the entire slope was in fact covered with plants of this species.

The species was also observed in the Willowmore area of the Eastern Cape (S.P. Bester pers. comm.) in North Kammanassie Sandstone Fynbos (Mucina & Rutherford 2006). Unfortunately, the observer was not able to collect material for herbarium specimens at this locality at the time and was unable to relocate the population on a subsequent visit, probably because the plants were not flowering. Another flowering population was observed in October 2001, ± 5 km north of Pofadder on the Onseepkans road, Northern Cape (G. Williamson pers. comm.). The plants were growing on the western aspect of a low quartzitic outcrop. Regrettably, no specimens could be made, but an illustration was made from field notes by G. Williamson (Figure 4). Barker collected the species in the same area in August 1954 and a specimen is housed at NGB (Baijnath 1977).

Bulbine triebneri was also recently collected on the Ouberg Pass, Northern Cape. Plants were found in full sun on a lower west-facing rocky scree slope, in Tanqua Escarpment Shrubland (Mucina & Rutherford 2006).

A few seeds were collected from the Graaff-Reinet population. They germinated rapidly in Pretoria and the seedlings flowered within their first season. The plants, although growing somewhat more robustly in cultivation than in the field, retained their distinguishing characters. The most interesting feature of this species is that the flowers seemingly open only in the very late afternoon for two to three hours at most, a pattern similar to some grassland species of *Trachyantha* Kunth. The only other *Bulbine* species where past midday flowering has been reported thus far is *Bulbine torsiva* G. Will. (Williamson 1996). By the time the flowers of *B. triebneri* open, those of the other yellow-flowered *Bulbine* species have already closed or are in the process of closing. Flowers of the genus are devoid of nectar and are visited mainly by bees for pollen. The specific time of day when the flowers are open and their white colour, suggest that *B. triebneri* might have undergone an evolutionary adaptation to a pollinator that differs from those of most other species of *Bulbine*. It would be useful to investigate the plant-pollinator relationships of the genus as a whole.

Additional material examined

EASTERN CAPE.—3224 (Graaff-Reinet): Graaff-Reinet, Urquhart Park, on slope next to road leading to dam wall (Van Ryneveld's Pass Dam), (–BA), R.R. Kloppe & A.W. Kloppe 214 (PRE).

NORTHERN CAPE.—3220 (Sutherland): Ouberg Pass, near lower end of pass (–AD), H.M. Steyn 810 (PRE).

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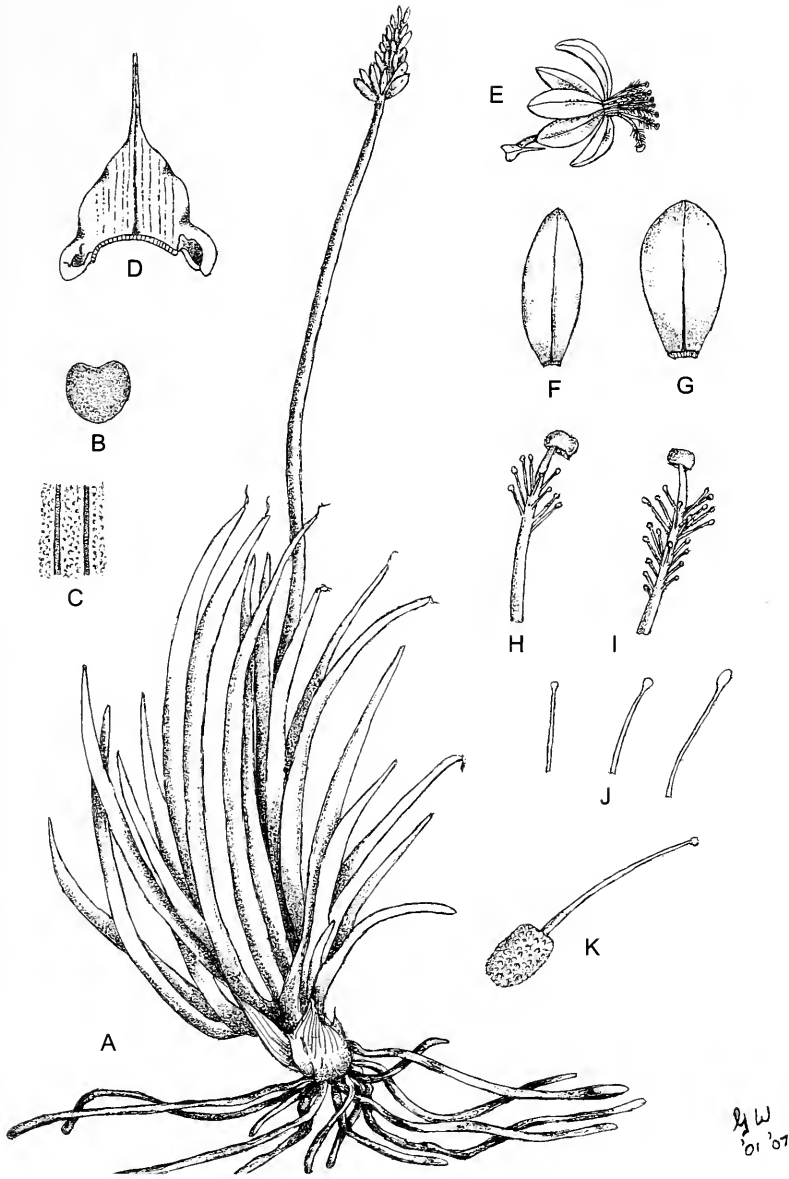


FIGURE 4.—*Bulbine triebneri*, G. & F. Williamson 5984. A, whole plant, longest leaf 248 × 3 mm; B, sectioned leaf, 3 × 2.5 mm; C, leaf surface with dark green veins; D, pedicel bract flattened, 1.8 mm wide at base, 2.5 mm long; E, flower, side view, pedicel ± 4.3 × 0.5 mm; F, outer tepal 6 × 1.8 mm; G, inner tepal 6 × 2.8 mm; H, outer stamen 3.7 mm long with anther 1 mm long; I, inner stamen 3.7 mm long with anther 0.6 mm long; J, glandular trichomes, longest 1.2 mm; K, ovary, style and stigma, overall 3.6 mm long. Artist: G. Williamson.

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ASPHODELACEAE

NOTES ON THE NOMENCLATURE AND TYPIFICATION OF *ALOE NATALENSIS* (ALOOIDEAE)

INTRODUCTION

The morphologically highly variable *A. arborescens* Mill. is widely distributed in southern and south tropical Africa (Smith *et al.* in review) and is important medicinally (Liao *et al.* 2006) and horticulturally (Van Jaarsveld 2002) far beyond its African range. Select variants [most importantly, *A. arborescens* Mill. var. *natalensis* (J.M.Wood & M.S.Evans) A.Berger] remain important in the context of biotechnological (Kawai *et al.* 1993) and pharmacological (Obata *et al.* 1993; Teradaira *et al.* 1993; Tsuda *et al.* 1993) research, particularly in Japan. In view of the recent taxonomic dismantling of *A. arborescens* (Van Jaarsveld & Van Wyk 2005), and consideration of infraspecific diversity for a CITES assessment (Smith *et al.* in review), we revisited its synonymy. This revealed both typification and protologue citation errors in respect of *A. natalensis* J.M.Wood & M.S.Evans.

NOMENCLATURE OF *ALOE NATALENSIS*

The name *Aloe natalensis* first appeared in the literature in a parochial report on the activities of the Colonial Herbarium in Durban, South Africa (today the KwaZulu-Natal Herbarium, NH). At that stage, the authors of the report (Wood & Evans 1901a) were uncertain, due to disruptions related to the South African [Anglo-Boer] War, whether their new taxa descriptions would first appear in print in the 39th volume of the *Journal of Botany, British and Foreign* to which they had earlier submitted it as part of an ongoing series called 'New Natal Plants'. As it turned out, the herbarium report was published first (before May 1901), as confirmed by the editor of the *Journal of Botany*, James Britten (see editorial note on page 169, vol. 39). Furthermore, the *Journal of Botany* publication (Wood & Evans 1901b) was only a verbatim repeat of Wood & Evans's earlier account. Although neither publication cites a voucher specimen, the name *Aloe natalensis* is considered to have been validly published in the Colonial Herbarium report (Wood & Evans 1901a) in terms of the *International Code of Botanical Nomenclature* (ICBN) (McNeill *et al.* 2006).

In volume 3 of his *Natal plants*, Wood (1902) profiles *Aloe natalensis* more comprehensively and provides a detailed illustration. Under the heading 'Habitat' he cites the following: 'Natal: Midlands, 800 to 3,000 feet alt, usually in rocky situations; Inanda and Noodsberg, Wood, cultivated in Natal Botanic Gardens, Wood No. 4342'. This latter specimen was prepared from a plant grown in the Natal Botanic Gardens (today the Durban Botanic Gardens) and labelled '*Aloe arborescens* Mill.' in the case of the NH specimens, and '*A. purpurascens*' in the case of a duplicate sent to Kew. Notably, Wood, who as Curator of NH from 1882 till 1915 (Schrire 1983), never changed the name of the NH specimen label to *A. natalensis*, despite citing it as a voucher for the name in several publications, the first of which was Wood (1902). He continued to uphold his concept

of *natalensis* at species level in various publications (Wood 1908; 1912; 1915) until the time of his death. Considering the manner in which Wood cited specimens for other species treated in the *Natal plants* series, it would appear that the unnumbered reference to 'Wood' may imply a Wood specimen submitted to the Herbarium without a collector's number. Such unnumbered Wood specimens [of *A. arborescens*] are to be found in the NH collection, but none antedate the Colonial Herbarium report. Therefore it is more likely that the citation of 'Wood' in *Natal plants* (Wood 1902) refers to sight records of this taxon at both 'Inanda and Noodsberg', localities referred to in the *A. natalensis* tableau. Berger (1908) referred to 'Wood n. 5019! und 5020!' in his treatment of '*A. arborescens* Mill. var. *natalensis* (Wood et Evans) Berger'—material that had earlier been deposited at NH under Wood 4342. Berger evidently cited the separate herbarium accession numbers rather than Wood's single collection number in view of the anomalous referencing situation with which he was confronted. Both specimens of Wood 4342 have survived at NH and each provides representative vegetative, and reproductive, material. One of these (in NH5019) is more complete in that it has a seed vial labelled '*Aloe natalensis*' attached to it.

Kew holds a duplicate of Wood 4342 but as the material was received by that institution on 4 September 1890, and as Wood never subsequently travelled to Kew, it is reasonable to assume that this particular specimen was not used in the course of describing *A. natalensis* a decade later: duplicates were after all available to Wood and Evans at NH.

Seeing that no voucher was cited in the protologue, a lectotype is here designated. From the specimens that were at the disposal of the authors, we chose the most complete duplicate of Wood 4342, namely the one with the NH accession no. 5019. The duplicate in NH and the one at K are considered to be isocototypes.

Despite the unambiguous statement of Britten, subsequent regional treatments of *Aloe* L. have incorrectly cited the protologue, in respect of both place and date of publication (Reynolds 1950; Glen & Hardy 2000). In their treatment of the genus *Aloe* for the *Flora of southern Africa*, Glen & Hardy (2000) cite the following protologue publication: *A. natalensis* J.M.Wood & M.S.Evans: 9 (1900) [cited in their bibliography as: 'Durban Botanic Society Report on Natal Botanic Gardens for the year 1900'. This was published in 1901]. They give the following type citation: KwaZulu-Natal, Inanda, Wood 4342 (NH, holo.!: K!; PRE, photo.!). The cited PRE photograph was not found nor could the origin of any of the material seen be traced to Inanda.

We conclude that the authorship and place of valid publication of *Aloe natalensis* should be cited as follows:

Aloe natalensis J.M.Wood & M.S.Evans in J.M. Wood in Colonial Herbarium. Report for the year 1900: 9 (1901a).

The type of *Aloe natalensis* should be cited as follows:

TYPE.—Natal, 2931 (Stanger): ex hort., Botanic Gardens, Durban, (–CC), 10-6-1890, *Wood 4342 in NH5019* (NH, lecto.), *Wood 4342 in NH5020* (NH, isolecto.), *Wood 4342* (K, isolecto.).

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ERRATA IN BOTHALIA 37,2 (2007)

MOFFETT, R.O. 2007. Name changes in the Old World *Rhus* and recognition of *Searsia* (Anacardiaceae). *Bothalia* 37,2: 165–175.

Page 169: ***Searsia krebsiana***: replace (*Presl ex Engl.*) with (*C.Presl ex Engl.*).
Rhus krebsiana: replace *Presl ex Engl.* with *C.Presl ex Engl.*

Page 170: ***Searsia natalensis***: replace (*Bernh. ex Krauss*) with (*Bernh. ex C.Krauss*).
Rhus natalensis: replace *Bernh. ex Krauss* with *Bernh. ex C.Krauss*.

Page 171: ***Searsia pterota***: replace (*Presl*) with (*C.Presl*).
Rhus pterota *Presl* in *Botanische Bemerkungen*: 44 (1884) should be:
Rhus pterota *C.Presl* in *Botanische Bemerkungen*: 41 (1844).

Page 173: ***Searsia volkii***: replace (*Süsseng.*) with (*Suess.*).
Rhus volkii: replace *Süsseng.* with *Suess.*

Page 174: *PRESL, K.B.* 1884. *Botanische Bemerkungen*: 43–45. Haase, Prague should be:
PRESL, K.B. 1844. *Botanische Bemerkungen*: 40–42. Haase, Prague.

HYACINTHACEAE

DRIMIOPSIS LINIOSETA, A NEW SPECIES FROM THE SEKUKHUNELAND CENTRE OF ENDEMISM, SOUTH AFRICA

The most recent taxonomic treatise on *Drimiopsis* Lindl. & Paxton is by Müller-Doblies & Müller-Doblies (1997). They recognized nine infrageneric taxa in southern Africa and provided keys to their identification. Lebatha (2005) subsequently revised both the subtropical and tropical African material. In her study it became evident that a plant collected by the first author and Sharon Turner in Sekukhuneland, South Africa was new to science as it could not be keyed out using Müller-Doblies & Müller-Doblies (1997). It also displayed a unique set of morphological character states when compared to the other known species.

Different opinions exist regarding the generic status of *Drimiopsis* in relation to *Resnova* Van der Merwe and *Ledebouria* Roth. In this regard we subscribe to Lebatha *et al.* (2006) who view any formal generic reclassification in the Ledebouriinae as premature, for example as recently proposed by Manning *et al.* (2004). Hence this new species is placed in *Drimiopsis*.

Drimiopsis linioseta A.J.Hankey & P.D.Lebatha, sp. nov., *D. reilleyanae* U.Müll.-Doblies & D.Müll.-Doblies similis, sed praesentia pseudopetioli, et setis solum seriebus rectis differt.

TYPE.—Mpumalanga, 2529 (Witbank): between Roosenekal and Lydenburg, west-facing slopes opposite La Ronelle guest house, (–BB), 25 November 1999, Hankey & Turner 900 (PRE, holo.; K, iso.).

D. liniopapilla Lebatha, nom. inval., non rite publicatum (2005).

Plants 100–140 mm high, leaves appearing before or with the flowers, bulbaceous. *Bulbs* hypogaeal, ovoid to oblong, 30–40 × 30–45 mm, gregarious, nonstoloniferous, whitish; apices truncate; bulb scales loosely packed, without threads when torn; outer scales white and fleshy; dead bulb scales absent. *Leaves* 1 or 2, conduplicate, cordiform to broadly lanceolate, 30–80 × 100–140 mm, without threads when torn, mostly unspotted adaxially, immaculate or variously streaked and mottled purple/brown abaxially; apex acuminate, base attenuate, amplexicaul on scape; indumentum present, in form of hairs arranged in rows on adaxial and abaxial lamina surface, pseudopetiole and scape; lamina margin entire becoming crenulate towards base, soft, pseudopetiolate; pseudopetiole off-white and horizontally banded with purple/brown, especially toward base, ± as long as lamina. *Inflorescence* 1(2) per bulb, a dense erect raceme and flaccid post anthesis, ± as long as leaves; rachis ovoid-terete, 20–40 mm long; peduncle dark green-purplish; bracts in mature inflorescence vestigial. *Flowers* 20–30, densely distributed becoming more lax post anthesis, small, 2–3 mm long, actinomorphic, sex-tepalous, hyacinth-scented, inner and outer lobes becoming green to purple-brown, post anthesis; hypanthium inconspicuous with base rounded, pedicellate; pedicel glabrous, 1 mm or less. *Tepals* dimorphic, outer tepal

lobes purple-brown, apices and margins whitish in bud becoming whitish green at anthesis, partially spreading, longitudinally cucullate, apically conduplicate; inner tepal lobes purple-brown with whitish green margins and yellowish green conduplicate apices, hardly spreading at anthesis, connivent, shorter than outer whorl, longitudinally cucullate. *Stamens* 6, greenish to whitish, erect, epitepalous, as long as pistil; filaments free, deltoid to acuminate; anthers dorsifixed. *Gynoeceium* tricarpellate; ovary sessile, globose, whitish to greenish; ovules 2 per locule; style as long as ovary, terete; stigma trilobed. *Flowering time*: late spring and early summer. Figure 5.

Etymology: the specific epithet *linioseta* is named for the conspicuous rows of setae that adorn all parts of the plant except the flowers.

Diagnostic features and discussion: the phylogenetic relationships within *Drimiopsis* are unclear at present. A cladistic analysis by Lebatha (2005) grouped *D. linioseta* with undescribed entities as well as *D. atropurpurea* N.E.Br. and *D. pusilla*. U.Müll.-Doblies & D.Müll.-Doblies. However, these groupings are tentative due to the absence of synapomorphies and bootstrap support. In terms of appearance, *D. linioseta* may also be related to *D. reilleyana*. *Drimiopsis linioseta* is characterized by leaves possessing hairs exclusively in rows that trace the veins in the leaf (Figure 6). This character state distinguishes *D. linioseta* from *D. reilleyana* as well as the prominent pseudopetiole, longer inflorescence and larger stature and smaller flowers (Table 1). *D. comptonii* U.Müll.-Doblies & D.Müll.-Doblies also possess epidermal structures in rows, as well as scattered in between. *D. linioseta* is 100–140 mm high at anthesis with larger conduplicate laminae, whereas *D. comptonii* is a dwarf species ± 30–60 mm high at anthesis, with flat to somewhat recurved laminae. The hairs in *D. comptonii* also possess a swollen base which does not occur in *D. linioseta*. Furthermore, *D. linioseta* also differs from *D. comptonii* in the flowers that are densely distributed in the inflorescence, are minutely pedicellate ± 1 mm long, and yellowish green as opposed to sparsely distributed purple-blue flowers with pedicels ± 0.4 mm long. Other species that possess hairs on the leaves are *D. atropurpurea*, *D. pusilla* and *D. reilleyana*, but here the distribution of the hairs differs (Table 1).

In the past, *Drimiopsis linioseta* may have been misidentified as *D. burkei* subsp. *burkei*. However, as mentioned, *D. linioseta* differs not only by the possession of rows of hairs, but also by the possession of a pseudopetiole, a state not found in *D. burkei* subsp. *burkei*. In this regard, *D. linioseta* resembles *D. atropurpurea*. However, the possession of well-defined rows of hairs again as compared to longer more scattered hairs, as well as flower colour—purple in *D. atropurpurea*—sets them apart (Table 1).

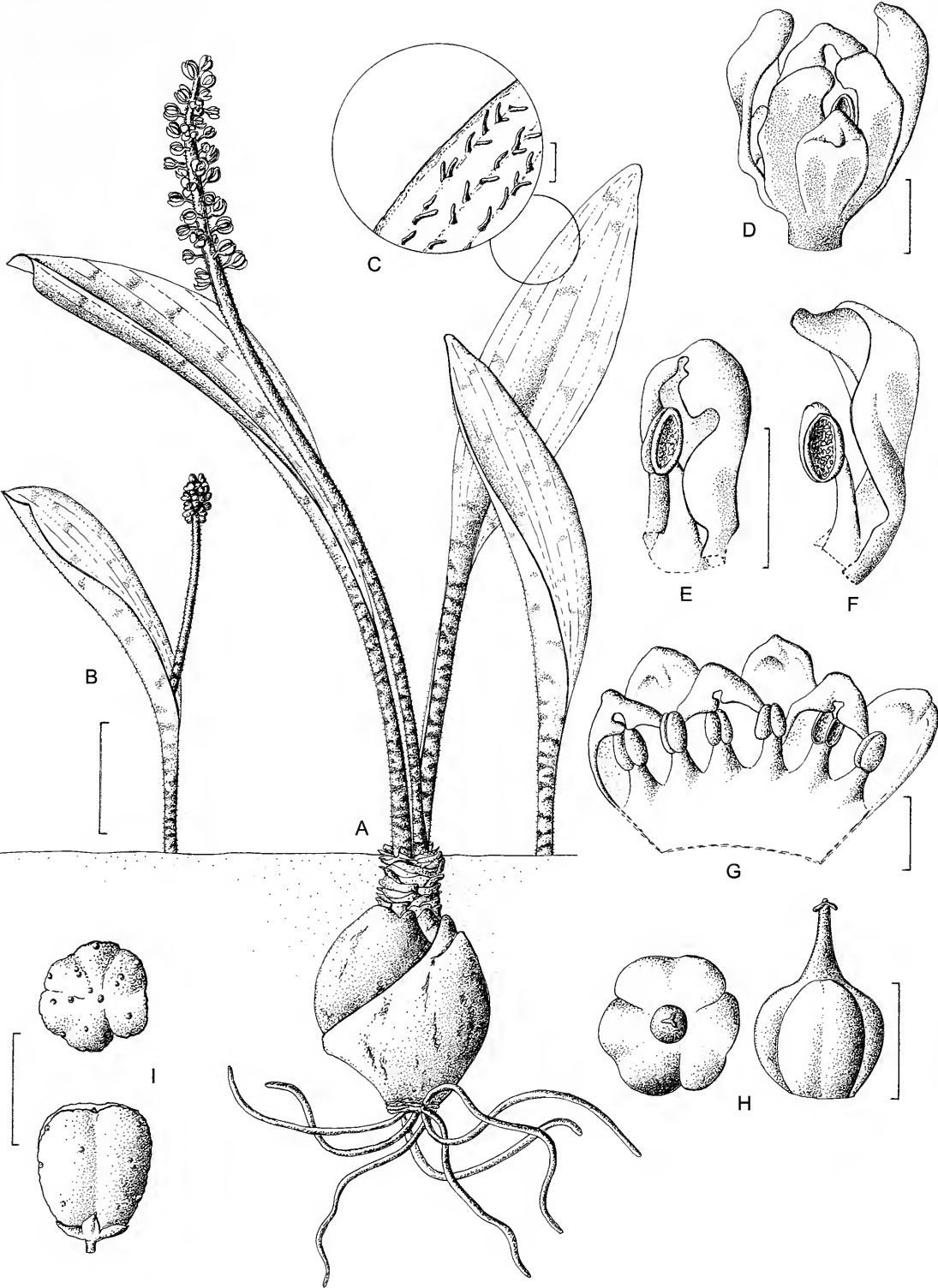


FIGURE 5.—*Drimiopsis linfosea*, Hankey & Turner 900. A, bulb and plant, $\times 1$; B, inflorescence and leaf; C, indumentum; D, flower; E, inner tepals and stamen; F, outer tepal and stamen; G, opened perianth. H, gynoecium: left, from above; right, from side. I, capsule: top, from above; bottom, from side. Scale bars: B, C, 20 mm; D, G, H, 1 mm; E, F, 2 mm; I, 7 mm. Artist: S. Burrows.

TABLE 1.—Principal differences between *Drimiopsis linioseta* and other species of *Drimiopsis* possessing an indumentum

	<i>D. linioseta</i>	<i>D. reilleyana</i>	<i>D. atropurpurea</i>	<i>D. comptonii</i>	<i>D. pusilla</i>
Pseudo-petiole length	About half as long as lamina	Absent or very short ($\frac{1}{6}$ length of lamina)	Longer than lamina	Inconspicuous	Absent
Indumentum distribution	Linear rows on nerves	Scattered	Scattered	Linear rows on nerves and scattered	Scattered
Flower colour	Yellowish green to green	Whitish green	Purple	Purple-blue	Purplish green
Flower size	2–3 mm	4–5 mm	2–4 mm	3–4 mm	1–2 mm
Leaf margin	Entire to crenulate	Entire to crenulate	Entire	Entire to crenulate	Entire to crenulate

The following couplet can be inserted into the key provided in Müller-Doblies & Müller-Doblies (1997) to assist in the identification of this species:

3c Leaves 1 or 2, setose, with setae arranged in longitudinal rows, pseudopetiole ± length of lamina *D. linioseta*

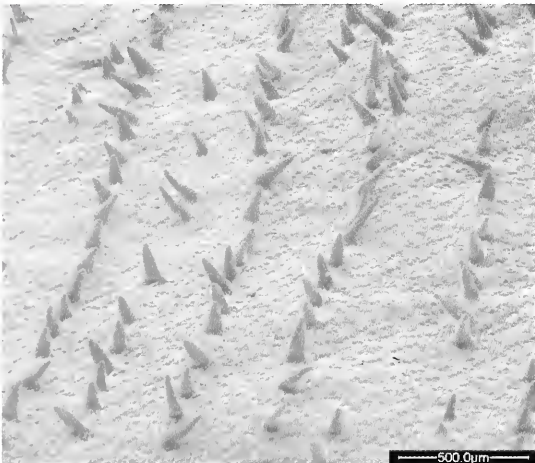


FIGURE 6.—*Drimiopsis linioseta*, Hankey & Turner 900. SEM photo of linear setae on adaxial leaf surface.

Distribution and habitat: *Drimiopsis linioseta* has been recorded from the Sekukhuneland area of Mpumalanga, where it is confined to the vicinity of Roossenekal and Tonteldoos (Figure 7). It grows among rocks and boulders, and in humus-rich pockets in the shade of trees and shrubs often at the base of large boulders. The known area of distribution places it in the Sekukhuneland Centre of Endemism (Van Wyk & Smith 2001) and the vegetation type Sekukhune Montane Grassland (Mucina & Rutherford 2006).

Conservation status

Due to the limited distribution range and the ever-present threat of habitat loss from mining in this area, we consider the species at present to be best described as vulnerable and give it a VU D2 ranking according to the IUCN (2000) criteria.

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thanked for the SEM contribution, Ronell Klopper for her assistance in the National Herbarium and Sandie Burrows for the line drawing.

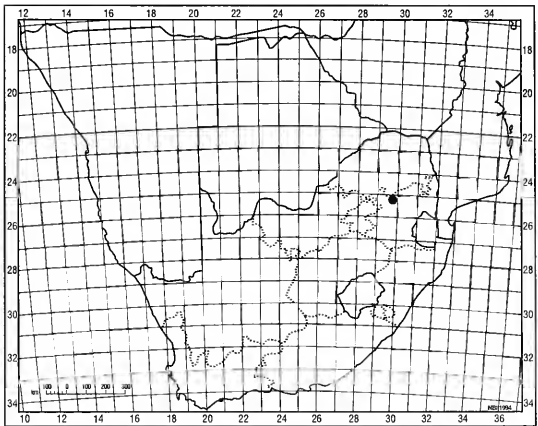


FIGURE 7.—Known distribution of *Drimiopsis linioseta*.

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ROSACEAE

VALIDATION OF THREE *CLIFFORTIA* TAXA IN *BOTHALIA* 37,1 (2007)

In the recent article on *Cliffortia* (Whitehouse & Fellingham 2007), the following new names were invalidly published, as explicit indications of the herbaria holding the holotypes were accidentally omitted: *Cliffortia sparsa*, *C. cuneata* var. *cylindrica* and *C. filifolia* var. *arenaria*. As this is contrary to the International Code of Botanical Nomenclature: Art. 37.7 (McNeill *et al.* 2006), the correct citations, including location of the holotype, are given here:

***Cliffortia sparsa* C.Whitehouse, sp. nov.**, in *Bothalia* 37: 16 (2007).

TYPE.—Western Cape, 3419 (Caledon): Caledon District, Hottentots Holland Nature Reserve, around Nuweberg Forest Station, 560 m, (–AA), 25 Oct. 2001, *Whitehouse* 283 (BOL, holo.!; NBG!).

***Cliffortia cuneata* var. *cylindrica* C.Whitehouse, var. nov.**, in *Bothalia* 37: 18 (2007).

TYPE.—Western Cape, 3418 (Simonstown): Caledon District, Arieskraal, south-facing slopes on Bokkeveld shale above Arieskraal Dam, 215 m, (–BB), 29 Nov. 2000, *Whitehouse* 166 (BOL, holo.!; NBG!).

***Cliffortia filifolia* var. *arenaria* C.Whitehouse, var. nov.**, in *Bothalia* 37: 20 (2007).

TYPE.—Western Cape, 3422 (Mossel Bay): George District, sand dunes E of Wilderness, (–BA), 3 Dec. 1951, *Esterhuysen* 19336 (BOL, holo.!; NBG!, PRE!).

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OXALIDACEAE

A NEW SPECIES OF *OXALIS* FROM THE HANTAM-ROGGEVELD PLATEAU, NORTHERN CAPE, SOUTH AFRICA

Oxalis L. is a large genus of more than 800 species, and although world-wide in distribution, most of the species, some 90%, are concentrated in South-Central America (\pm 500 spp.) and South Africa (\pm 210 spp.). Among the South African species, all but a half-dozen are concentrated in the winter rainfall region, in the Fynbos and Succulent Karoo Biomes (Oberlander *et al.* 2002).

Although now over 60 years old, the revision of the South African species of *Oxalis* by Salter (1944) remains the only complete study of the genus in the subregion. Salter travelled extensively through the southwestern Cape and Namaqualand but the adjacent Hantam and Roggeveld escarpments remained mostly inaccessible to him, which is why a species as common and attractive as the one described here eluded him.

***Oxalis odorata* J.C.Manning & Goldblatt, sp. nov.**

Planta acaulescens stolonifera, foliis basalibus, foliolis (2)3 vel 4(5) ellipticis vel oblanceolatis ad anguste oblanceolatis, conduplicato-falcatis, emarginatis, (7–)10–15(–25) \times 2–5(–8) mm, pallide griseo-viridibus adaxiale minute papillato-puberulis, glabris, subglabris vel sparse pubescentibus, atroviridibus abaxiale callosis dispersis punctiformibus nigris, floribus lilacinis vel albis distale pallide lilacinis tubo viridi fauce viridi vel purpureo, grateodoratis, sepalis lanceolatis, acutis vel obtu-

sis 4–5 \times 1.0–1.25 mm, marginibus sparse ciliatis distale et callis aurantiacis angustis ad apicem et in medio, petalis oblique oblanceolatis 15–25 \times 5–7 mm, filamentis edentatis, antheris ellipsoideis.

TYPE.—Northern Cape, 3220 (Sutherland): 7 km south of Sutherland, top of Verlatekloof Pass, Farm Jakkalsvlei, seasonally wet clay flats, (–BC), 2 June 2007, *Manning* 3095 (NBG, holo.; MO, iso.).

Deciduous, acaulescent bulbous herb, not tufted. *Bulb* narrowly ovoid, 15–20 \times 7–10 mm; outer tunics papery, brown, minutely striatulate. *Rhizome* 25–100 mm long, bearing brown, papery scales and developing a slender stolon in each scale axil; aerial stem absent. *Leaves* 4–18, basal; petioles 10–40(–100) mm, glabrous or thinly patent-pubescent, reddish, outer dilated or scale-like below basal articulation; leaflets (2)3 or 4(5), elliptic or oblanceolate to narrowly oblanceolate, conduplicate-falcate, emarginate, (7–)10–15(–25) \times 2–5(–8) mm, pale matte greyish green and minutely papillate-puberulous adaxially, glabrous, subglabrous or thinly pubescent and darker green abaxially with scattered, punctiform, black calli. *Peduncles* 1-flowered, 12–30 mm long, mostly a little shorter than leaves, glabrous or thinly patent-pubescent, with 2 subopposite, subulate, glabrous bracts inserted in distal half 1–5(–7) mm below flower. *Flowers* tristylous, lilac or white flushed pale lilac, with pale

green, narrowly funnel-shaped tube, veins darker green or purple in throat, sweetly scented; sepals lanceolate, acute or obtuse, $4-5 \times 1.0-1.25$ mm, adpressed-pubescent or subglabrous with few short hairs towards base, margins sparsely ciliate distally, with narrow orange calli at apex and towards midline; petals adhering for ± 6 mm, obliquely oblanceolate, $15-25 \times 5-7$ mm; lamina obtuse, \pm twice as long as claw, glabrous or ciliate on outer margin, with or without several elongated calli near apex. *Stamens*: filaments erect, shorter 4–5 mm long, longer 6–7 mm long, longest 8–9 mm long and exerted ± 3 mm from tube, minutely glandular-pubescent, edentate; anthers ellipsoid, ± 0.75 mm long, yellow. *Ovary* densely hairy in distal half with a mixture of short, glandular hairs and longer, unicellular, eglandular hairs; locules 2-ovulate; styles minutely glandular-pubescent. *Capsules and seeds* unknown. *Flowering time*: mid-May to mid-June, rarely to late June. Figure 8.

Distribution and ecology: known from the summit of the Hantamsberg at Calvinia and from the Roggeveld Escarpment, from near Middelpoos and Sutherland

(Figure 9). The species is locally common, forming large populations on seasonally wet flats or around the margins of ephemeral pools in shallow soil on dolerite sills, multiplying and spreading through the production of axillary stolons from the scales along the rhizome.

Diagnostic characters and affinities: the pale lilac flower of *Oxalis odorata* with a slight greenish or pink eye, is sweetly scented during the day. Floral fragrance in *Oxalis* is extremely rare, and its occurrence is not mentioned by Salter (1944). The leaves of *O. odorata* are highly distinctive, with a pale, greyish green, matte upper surface densely covered with minute papillae, contrasting with the smooth or sparsely pubescent, darker green underside. Electron microscopic examination of the leaf surface shows the adaxial epidermal cells to be relatively small, highly domed, and covered with a thick coating of epicuticular wax platelets (Figure 10A, B), which cause the characteristic greyish bloom on the leaf upper surface. The abaxial epidermal cells, in contrast, are larger, with a thick, laevigate cuticle lacking distinctive epicuticular wax deposits, and those over the midline are longitudi-

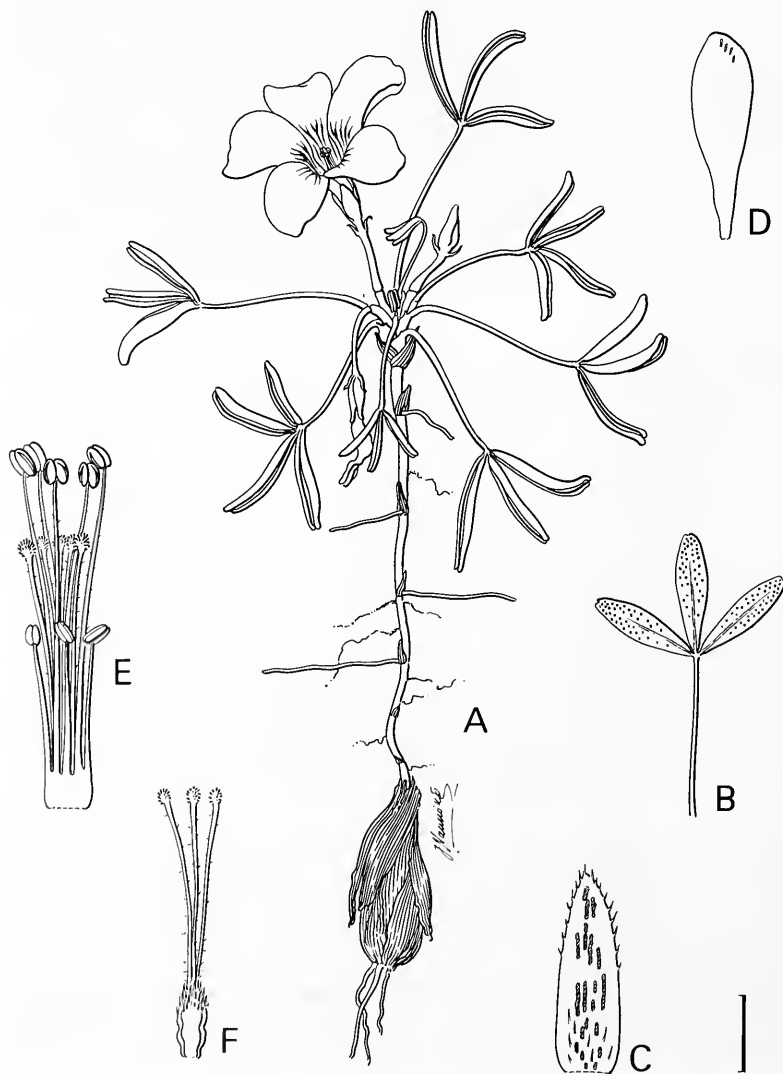


FIGURE 8.—*Oxalis odorata*, Manning 3095. A, whole plant; B, single leaf flattened out showing adaxial surface. C–F, floral details: C, detached sepal; D, detached petal; E, stamens and ovary; F, ovary (rear two styles not shown). Scale bar: A–C, 10 mm; D–F, 2 mm. Artist: John Manning.

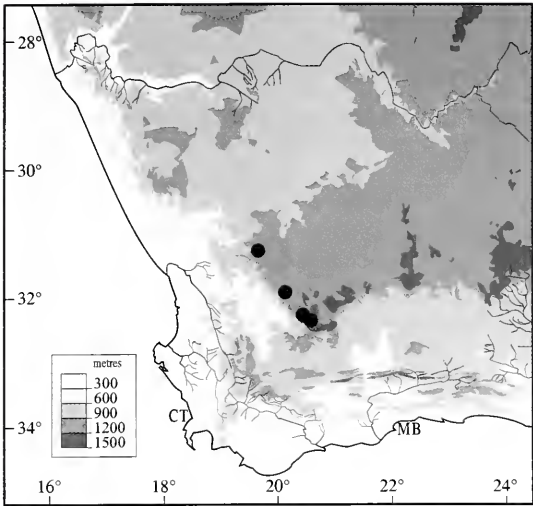


FIGURE 9.—Known distribution of *Oxalis odorata*.

nally elongated (Figure 10C). Stomata are restricted to the adaxial leaf surface, where they are protected by the conduplicate folding of the blade.

Salter (1944) divides the South African species of *Oxalis* with 1-flowered peduncles into eight sections. Among these, *O. odorata* keys out to section *Angustatae* Salter subsection *Lineares* Salter on the basis of its relatively narrow leaflets more than twice as long as broad. It is somewhat anomalous here in several features, notably its acaulescent habit and the elliptical leaflets that lack paired apical calli. In section *Latifoliae* Salter, however, three other species of *Oxalis* are known with similar discolorous, elliptical to ovate leaflets and mauve flowers with some sort of darker eye in the mouth of the tube (*O. callosa* R.Knuth, *O. petiolulata* L.Bolus and *O. stokoei* Weintraub) and the relationships of *O. odorata* are more likely to lie with them. Although not mentioned by Salter (1944), the pale greyish upper leaf sur-

face is characteristic of this small group of species. In this group, *O. petiolulata* from the Cedarberg has ebracteate peduncles and leaflets with broadly ovate leaflets bearing a single line of black calli along the margin. This contrasts with the bracteate peduncles and leaflets with scattered, punctiform calli found in the remaining two species as well as in *O. odorata*. Among these, *O. stokoei* from the Hex River Mountains is distinguished by its unusual, subfibrous outer bulb tunics that split into matted segments.

Thus, *O. odorata* is most likely to be confused with *O. callosa*, another early-blooming species endemic to the Bokkeveld Plateau and Hantam, and which also produces stolons from the rhizome. Several vegetative and floral characters separate the two. The bulbs in *O. callosa* are \pm ovoid and the species invariably produces trifoliolate leaves with obovate leaflets $6-8 \times 4-6$ mm, thus 1.5–2.0 times as long as wide, with the upper surface \pm smooth and the lower surface densely adpressed-pubescent and marked with reddish or orange calli; the calli on the sepals are marginal; and the flowers have a conspicuous dark red eye in the mouth. In contrast, *O. odorata* has narrowly ovoid bulbs and variably foliolate leaves, usually with 3 or 4 leaflets but not uncommonly up to 5, which are narrowly elliptical-oblongate and mostly $10-15 \times 2-5$ mm, thus (3–)4–8 times as long as wide, with the upper surface papillate-puberulous and the lower subglabrous or sparsely pubescent and marked with black calli; sepals with the calli concentrated towards the midline; and flowers with the central eye only weakly developed. In addition, *O. callosa* is not uncommonly caulescent and favours damp clay flats over shale, although it will also grow in dolerite outcrops, whereas *O. odorata* is strictly acaulescent and restricted to seasonally wet or waterlogged habitats over dolerite sills.

Additional specimens examined

NORTHERN CAPE.—3119 (Calvinia): summit of Hantamberg, (–BD), 31 May 1999, Manning 2223 (NBG). 3120 (Williston): 66 km from Calvinia on Blomfontein road to Middelpos, (–CC), 4 June

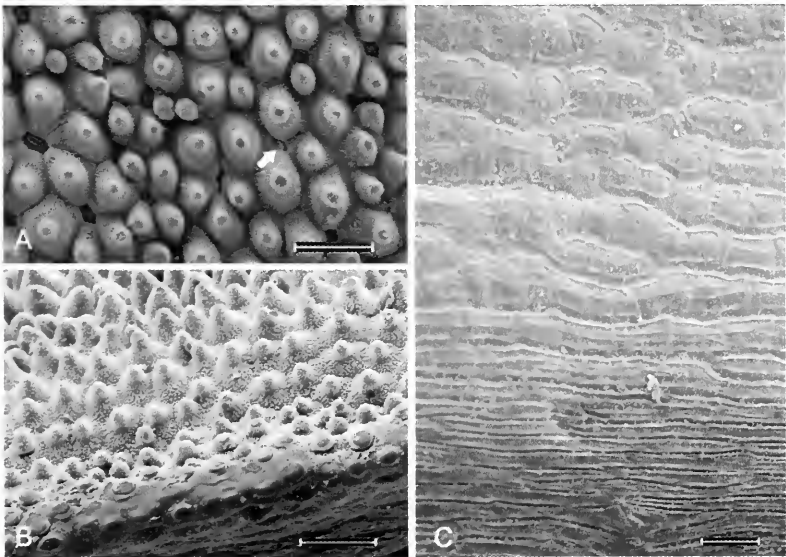


FIGURE 10.—Scanning electron micrographs of leaflet surface micromorphology. A, adaxial surface (stoma arrowed); B, leaflet margin; C, abaxial surface with longitudinally elongated epidermal cells with narrower epidermal cells along midline. Scale bars: 30 μ m.

1980, *Goldblatt 5533* (MO, NBG, PRE). 3220 (Sutherland): top of Verlatekloof Pass, (–DA), 26 June 1977, *M.B. Bayer 906* (NBG); 25 May 2003, *Manning 2808* (NBG).

ACKNOWLEDGEMENTS

Our thanks to Elizabeth Parker for facilitating the trip to collect type material of *Oxalis odorata*. The micrographs were taken at the Electron Microscopy Unit of the University of Cape Town and the plate was prepared by Michelle Smith. Material was collected under a permit from Northern Cape Nature Conservation.

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IRIDACEAE

ROMULEA LUTEA AND *R. TUBULOSA* (CROCOIDEAE), TWO NEW SPECIES FROM NAMAQUALAND, SOUTH AFRICA

Romulea Maratti, with ± 95 spp., is one of the larger genera in subfamily Crocoideae, the largest of the seven subfamilies now recognized in Iridaceae (Goldblatt & Manning in press). The genus is distributed through eastern sub-Saharan Africa, the Mediterranean and the Near East, with its centre of diversity in the winter rainfall region of southern Africa, where 76 species are now known to occur (De Vos 1972, 1983; Manning & Goldblatt 2001, 2004, 2006), including the two described here. The current taxonomy of the genus recognizes two subgenera and five sections, based largely on characters of the corm (Manning & Goldblatt 2001, 2004), which provide essential information for accurate identification of many species. Flower structure, with few exceptions, is conservative (Goldblatt *et al.* 2002).

Since the last review of the genus (Manning & Goldblatt 2001), three new species have been discovered and named (Manning & Goldblatt 2004, 2006) and field work in Namaqualand in 2007 has resulted in the discovery of a further two novelties, which we describe here.

Romulea lutea J.C.Manning & Goldblatt, sp. nov.

Plantae 50–100 mm altae, caule subterraneo vel breviter supra terram producto, corno oblique complanato crista lunata ciliata, tunicis duris atrobrunneis, foliis 3, 1 basali, laminis anguste 4-sulcatis, inflorescentia floribus usque ad 4, bracteis 8–10 mm longis bractea externa subobtusata viridi vel purpurea suffusa marginibus translucentibus, interna acuta viridi marginibus latis translucentibus pallide brunneis striatis, floribus profunde cupuliformibus aureis externe viridibus cupulo 8–9 mm profundo, tubo perianthii infundibuliformi ± 3 mm longo parte inferiore ± 1 mm longo, tepalis oblanceolatis 11–13 \times 4–5 mm, staminibus flavis filamentis ± 4 mm longis minute pilosis in dimidio inferiore, antheris ± 4 mm longis, stylo in parte superiore in ramos ± 1 mm longos divisos, capsulis oblongo-ellipsoideis ± 8 mm longis, pedunculis recurvatis.

TYPE.—Western Cape, 3118 (Vanhynsdorp): coastal sandveld west of Koekenaap at Farm Skaapvlei, local in drainage line, (–AC), 24 August 2007, *Goldblatt & Manning 12868* (NBG, holo.; MO, PRE, iso.).

Plants 50–100 mm high; stem subterranean or shortly aerial. *Corm* subglobose, asymmetric, obliquely flattened towards base with crescent-shaped basal ridge; tunics hard, smooth, dark brown, split into numerous fine parallel fibrils on basal ridge and short fibrils up to 2 mm long above. *Cataphylls* 3, membranous, flushed greenish above ground. *Leaves* 3, lowermost one basal in plants with aerial stem, three to four times as long as flowering stems, blades narrowly 4-grooved, 60–150 \times ± 1 mm. *Inflorescence* of up to 4 solitary flowers; outer bract obtuse, 8–10 mm long, green or flushed purple, with narrow, translucent membranous margins, inner bract acute, thin-textured, green with broad translucent margins flecked pale brown, about as long as outer. *Flowers* deeply cup-shaped, cup 8–9 mm deep, golden yellow but pale green on reverse, ± 20 mm diam., faintly scented; perianth tube funnel-shaped, 3 mm long with lower narrow portion ± 1 mm long; tepals oblanceolate, 11–13 \times 4–5 mm. *Stamens* yellow; filaments inserted at base of cup, free, minutely pilose in lower half, 4 mm long; anthers parallel, 4 mm long. *Style* dividing opposite upper third of anthers, branches ± 1 mm long, divided for about half their length. *Capsules* oblong-ellipsoid, ± 8 mm long, peduncles recurved. *Seeds* unknown. *Flowering time*: August to early September. Figure 11.

Distribution and ecology: thus far known only from the Western Cape coast west of Koekenaap and north of the Olifants River Mouth, where we encountered several populations in seasonally moist drainage lines and depressions (Figure 12) on the adjacent farms Skaapvlei, Graafwater, and Brakvlei, although only material from the type locality was collected. The flowers open at about midday and close in the mid-afternoon and have a faint, somewhat sour fragrance.

Diagnosis and relationships: *Romulea lutea* is a relatively unspecialized member of section *Ciliatae* of subgenus *Romulea* and is distinguished from other members of the section primarily by its relatively small, completely yellow flowers. Plants are typically stemless or with a short aerial stem, and in the latter instance it is evident that they have a solitary basal leaf plus two

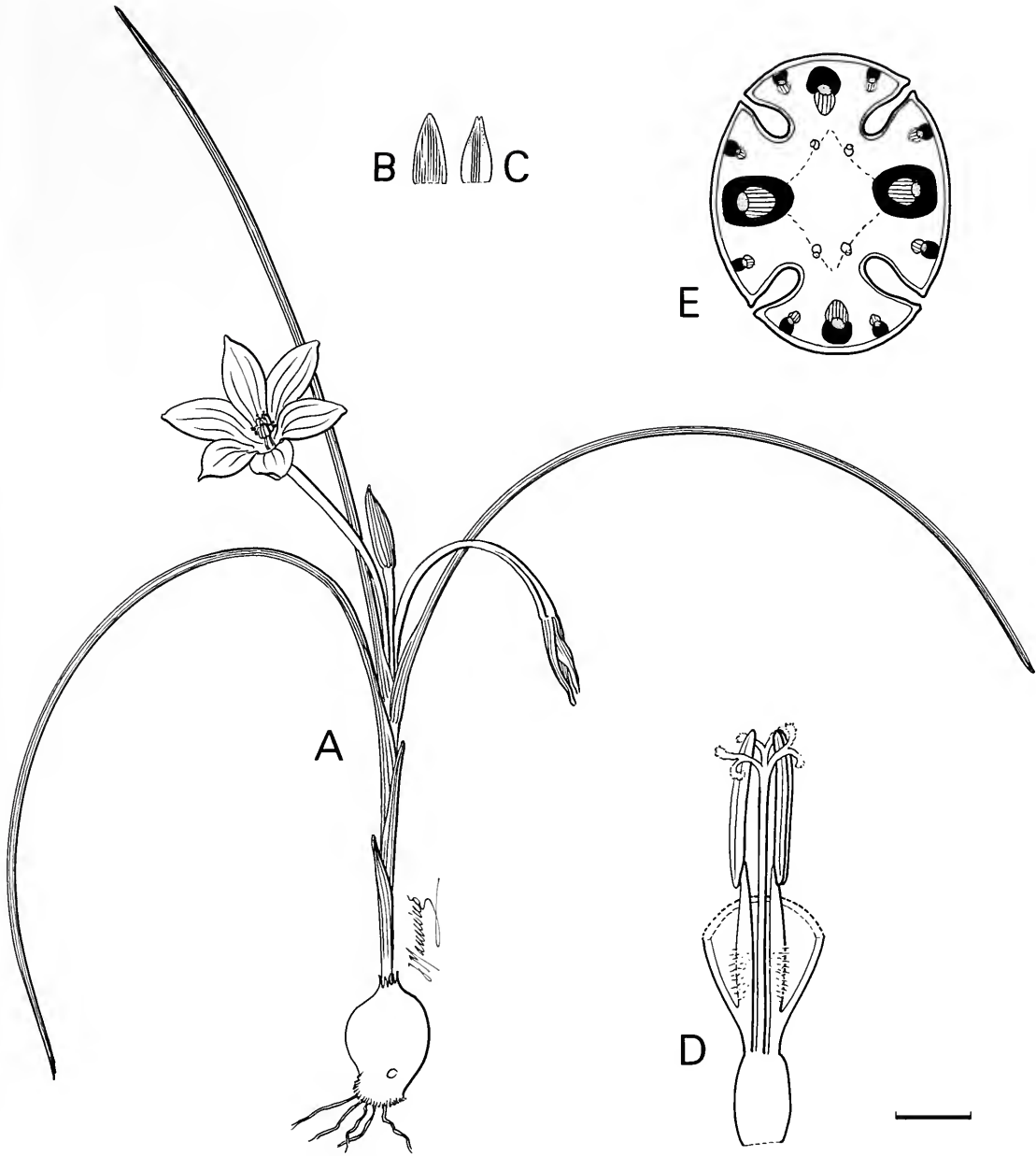


FIGURE 11.—*Romulea lutea*, P. Goldblatt & J.C. Manning 12868. A, whole plant; B, outer bract; C, inner bract; D, stamens and style; E, t/s leaf. Scale bar: A–C, 10 mm; D, 2 mm; E, 0.25 mm. Artist: John Manning.

cauline leaves. In stemless individuals, however, all three leaves appear to be basal and careful dissection is necessary, when it becomes evident that the inflorescences emerge from the axils of the upper two leaves. *R. lutea* resembles *R. tabularis* Bég. in general appearance, including the solitary basal leaf with unspecialized blade anatomy (Figure 11E), but this species has white or pale blue flowers with a yellow cup, typically a well-exserted aerial stem, and more membranous inner bracts. It also tends to occupy much wetter situations, typically water meadows, seepages, and shallow temporary pools. *R. lutea* also resembles *R. schlechteri* Bég., another white or cream- (rarely yellowish) flowered species that occurs

along the west coast as far north as Piketberg. Apart from flower colour, *R. schlechteri* differs from *R. lutea* in having two basal leaves and leaf blades in which the lateral primary veins lack complete sclerenchyma sheaths (De Vos 1972, fig. 13: 7). This difference in the number of basal leaves separates *R. lutea* from the other yellow-flowered members of section *Ciliatae* with relatively firm-textured inner bracts and complete bundle sheaths (*R. citrina* Baker, *R. elliptica* M.P.de Vos and *R. montana* Bég.), all of which have two rather than a solitary basal leaf. The hue of the flowers in *R. lutea* is also somewhat different, being golden yellow rather than canary yellow, and lacking any trace of dark markings in the throat.

***Romulea tubulosa* J.C.Manning & Goldblatt, sp. nov.**

Plantae 30–40 mm altae, caule subterraneo, cormo subglobose oblique complanato infra, tunicis duris atrobrunneis, foliis 3–5 arcuatis vel sinuatis (20–)30–45 × ± 0.5 mm anguste 4-sulcatis, sulcis ciliatis, inflorescentia floribus usque ad 4, bracteis 10–12 mm longis, bractea externa marginibus apicibusque membranaceis brunneis striatis, bractea interna ad apicem furcata, floribus ± hypocrateriformibus pallide flavis tepalis in parte dimidio atrobrunneis striatis rubro-brunneis externe, ± 15 mm diam., tubo perianthii 13–14 mm longo ± cylindrico, tepalis patentibus ellipticis 9–10 × 2.0–2.5 mm, staminibus flavis filamentis ± 1.5 mm longis glabris inclusis vel ± 0.5 mm exsertis, antheris ± 3 mm longis, stylo in parte superiore in ramos ± 1 mm longos diviso, capsulis seminibusque ignotis.

TYPE.—Northern Cape, 3018 (Kamiesberg): Kamiesberg, ± 2 km SE of Leliefontein near Naras Farm, local in renosterveld, (–AC), 28 August 2007, *R.* & *R. Saunders sub Manning 3117* (NBG, hol.).

Plants 30–40 mm high; stem subterranean. *Corm* subglobose, asymmetric, obliquely flattened towards base with crescent-shaped basal ridge; tunics hard, smooth, dark brown, split into numerous fine parallel fibrils on basal ridge and fibres up to 4 mm long above. *Cataphylls* 3, membranous, flushed greenish above ground. *Leaves* 3–5, arching or sinuous, up to three times as long as flowering stems, blade narrowly 4-grooved, (20–)30–45 × ± 0.5 mm, ciliate along grooves. *Inflorescence* of up to 4 solitary flowers; outer bract obtuse, 10–12 mm long, green, with broad, translucent membranous margins widening above into prominent, brown-flecked, membranous apex, inner bract notched apically, central portion firm-textured and green, with broad translucent margins and apex flecked dark brown, slightly longer than outer, central portion with ± 12 closely spaced veins. *Flowers* ± salver-shaped, 15–18 mm diam., pale canary yellow with median brown streak in throat, flushed reddish brown on reverse; perianth tube subcylindrical, 13–14 mm long, widening slightly from base to apex; tepals spreading, elliptical, 9–10 × 2.0–2.5 mm, outer slightly wider than inner. *Stamens* yellow; filaments inserted ± 1 mm below mouth of tube, shortly decurrent, glabrous, ± 1.5 mm long thus exserted up to ± 0.5 mm; anthers just exserted, parallel, ± 3 mm long. *Style* dividing opposite middle of anthers, branches ± 1 mm long, divided for ± half their length. *Capsules and seeds* unknown. *Flowering time*: August to early September. Figure 13.

Distribution and ecology: currently known from a single locality on the Kamiesberg in central Namaqualand, just southeast of Leliefontein near the farm Naras (Figure 12). The species is inconspicuous and appears to be relatively rare, occurring in small communities in open ground in renosterveld. No estimate of the number of individuals is available.

Diagnosis and relationships: a member of section *Ciliatae* of subgenus *Romulea*, the pale yellow, salver-shaped flowers of *R. tubulosa* are unique in the genus. The distinctive perianth, with ± cylindrical tube longer than the tepals, places it among just six known species

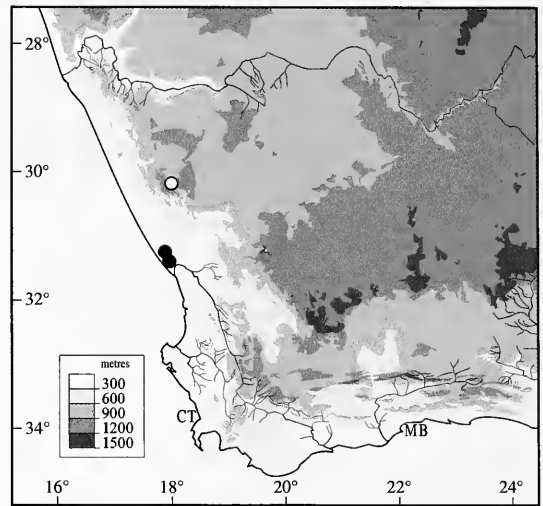


FIGURE 12.—Known distribution of *Romulea lutea*, ●; and *R. tubulosa*, ○.

in the genus with similar ± salver-shaped flowers, all of which have a white or, more usually, pink to purple perianth. Differences in vegetative features, including corm tunics, bract structure and leaf anatomy, suggest that this distinctive flower form has evolved repeatedly in the genus from the ancestral, funnel-shaped type, and is therefore no certain indicator of relationship. *Romulea tubulosa* appears to be no exception to this pattern. Three of the known species with such flowers, *R. albi-flora* J.C.Manning & Goldblatt, *R. hantamensis* (Diels) Goldblatt and *R. syringodeoflora* M.P.de Vos, are members of subgenus *Spatalanthus*, whereas the remaining three species, *R. kamensis* M.P.de Vos, *R. singularis* J.C.Manning & Goldblatt and *R. stellata* M.P.de Vos belong in subgenus *Romulea* (Manning & Goldblatt 2001). The flowers of *R. tubulosa*, with tepals just 9–10 × 2.0–2.5 mm, are among the smallest in the genus and comparable in size but not colouring to those of *R. stellata*. The oblique corms with finely fimbriate lower tunic margins of *R. tubulosa* place it among the latter group of species.

Within subgenus *Romulea* section *Ciliatae*, the distinctive bracts, with broad, translucent margins and apices, offer a better indication of the relationships of *R. tubulosa* than flower shape, and suggest that it is the fifth member of a group of species endemic to the higher lying parts of Namaqualand and the Richtersveld, centred on the Kamiesberg. This alliance comprises *R. maculata* J.C.Manning & Goldblatt (white flowers and purple-speckled cataphylls), *R. neglecta* (Schult.) M.P.de Vos (magenta flowers), *R. pearsonii* M.P.de Vos (yellow flowers) and *R. rupestris* J.C.Manning & Goldblatt (white flowers). The leaf anatomy of *R. tubulosa* is consistent with this putative relationship, namely the presence of vascular girders joining the primary bundles to the epidermis, and of sclerenchyma strands along the rib margins (Figure 13E). Both of these anatomical features are rare in subgenus *Romulea* but are characteristic of this alliance (Manning & Goldblatt 2001). The funnel-shaped flowers and relatively long floral bracts, 15–30 mm long, of these four members of the group are typical

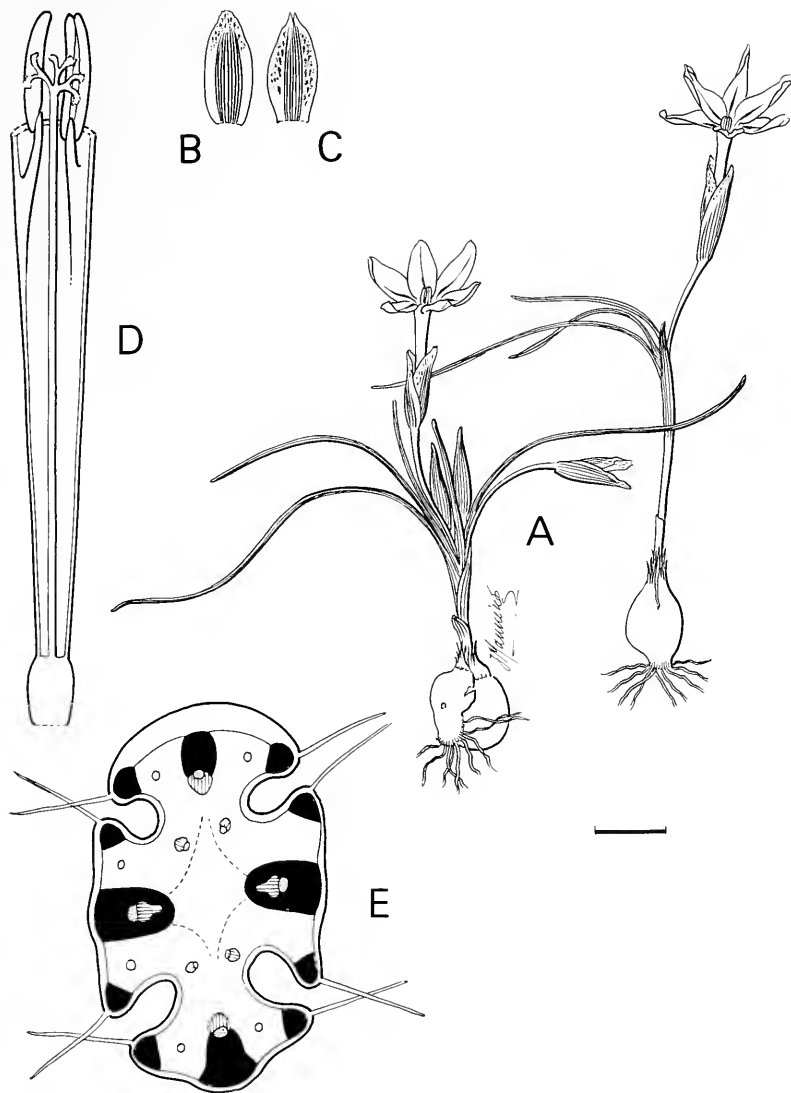


FIGURE 13.—*Romulea tubulosa*, *R. & R. Saunders sub Manning 3117*. A, whole plant; B, outer bract; C, inner bract; D, stamens and style; E, u/s leaf. Scale bar: A–C, 10 mm; D, 2 mm; E, 0.25 mm. Artist: John Manning.

of the genus, and differ markedly from the salver-shaped flowers of *R. tubulosa*, with a cylindrical perianth tube 13–14 mm long, and short bracts 10–12 mm long. Within the alliance, the brown-flecked bract margins and especially the yellow flowers, a colour that appears to be derived in the genus, suggest that *R. tubulosa* may be most closely allied to *R. pearsonii*. Apart from *R. tubulosa*, this species also has the shortest bracts in the group, 15–25 mm long.

Species of *Romulea* with salver-shaped flowers have in most instances been shown to be adapted for pollination by long-proboscid flies in the family Nemestrinidae, and conform to the *Prosoeca peringueyi* pollination guild in their magenta to purple flowers (Goldblatt *et al.* 2002; Goldblatt & Manning 2007). Although pollination by long-proboscid insects is likely for *R. tubulosa*, the yellow perianth suggests that different insect species are involved, most likely bee flies in the family Bombyliidae. The general resemblance in form, colour and in perianth tube length between the flowers of *R.*

tubulosa and those of co-occurring *Zaluzianskya benthamiana* (Scrophulariaceae) suggests that they belong to the same pollination guild.

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ASPHODELACEAE: ALOOIDEAE

NEW EVIDENCE IN SUPPORT OF A DISJUNCT DISTRIBUTION OF *ALOE KARASBERGENSIS*

Aloe karasbergensis Pillans was described by Pillans in 1928. It is a member of *Aloe* Section *Paniculatae* Salm-Dyck ex Kunth, which consists of six species namely *A. buhrii* Lavranos, *A. karasbergensis*, *A. komaggasensis* Kritzinger & Van Jaarsv., *A. kouebokkeveldensis* Van Jaarsv. & A.B.Low, *A. reynoldsii* Letty and *A. striata* Haw. *A. karasbergensis* and *A. komaggasensis* were reduced to subspecific status under *A. striata* by Glen & Hardy (1987, 2000). Lavranos (2004) argued that these two taxa should be recognized as separate species, since all six taxa in *A. Section Paniculatae* are easily distinguishable on the basis of vegetative and floral characters.

Aloe karasbergensis grows in semi-desert sand and stony mountain slopes in Namibia and the Northern Cape Province (Figure 14), especially in areas with very low and erratic rainfall (Glen & Hardy 2000). The distribution details provided by Reynolds (1950) indicate that this species occurs in southern Namibia from the Kubub Mountains south to the Richtersveld and Springbok area in South Africa, and then again near Kenhardt and south of Prieska. The distribution map provided by Glen &

Hardy (2000) clearly echoes this disjunct distribution. *A. karasbergensis* has also recently been found further West, on the Aurus Mountains, inside Diamond Area No. 1 in Namibia (E. van Jaarsveld pers. comm.)

Even though the only specimen in the National Herbarium, Pretoria (PRE) of *Aloe karasbergensis* from the central Northern Cape was collected by the revered J.P.H. Acocks, author of *Veld types of South Africa*, there has been some doubt on the validity of the disjunct distribution range of *A. karasbergensis*, as reflected in Reynolds (1950) and Glen & Hardy (2000).

A recent collection by the second author confirms that the species indeed occurs in the central Northern Cape Province.

NORTHERN CAPE.—3021 (Vanwykslei): Carnarvon area, Farm Konkakloof, (–DD), P.J. du Preez 3670 (BLFU).

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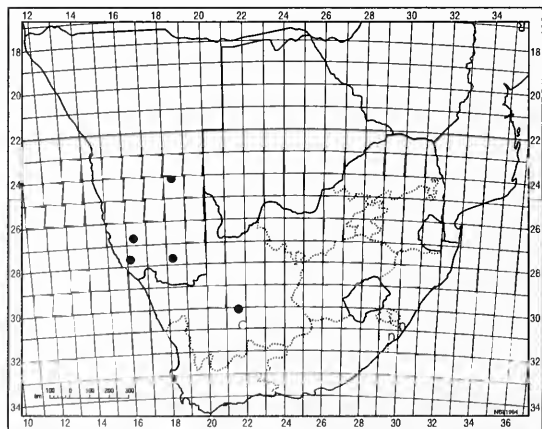


FIGURE 14.—Distribution of *Aloe karasbergensis*, based on specimens at PRE, ●; confirmed record in central Northern Cape, ○.

COLCHICACEAE

FURTHER NEW COMBINATIONS IN COLCHICUM

The recent sinking of the largely African genus *Androcymbium* Willd. into *Colchicum* L. (Manning *et al.* 2007) required the publication of more than 60 new names and combinations in the latter genus. Two taxon names were inadvertently omitted, and a further name in *Androcymbium* resulting from the transfer of *Merendera schimperiana* Hochst. (Persson & Del Hoyo 2007) requires a new combination in *Colchicum*. Despite differing opinions regarding generic circumscriptions (Persson 2007), the new combinations are effected here for curatorial purposes.

***Colchicum leistneri* (U.Müll.-Doblies & D.Müll.-Doblies) C.Archer, comb. nov.**

Androcymbium leistneri U.Müll.-Doblies & D.Müll.-Doblies in Feddes Repertorium 109: 557 (1998). Type: Northern Cape, 2824 (Kimberley): Nootgedacht, ± 10 mi. [16 km] SE of Barkly West, ± 3800 ft. [1 160 m], (–DA), 17.07.1959, *Leistner* 1969 (K, holo.; KMG, PRE!, iso.).

***Colchicum palaestinum* (Baker) C.Archer, comb. nov.**

Androcymbium palaestinum Baker in Journal of the Linnean Society, Botany 17: 445 (1879). Lectotype (designated by Greuter 1967: 253): 'Palaeina prope Hicosolymam', *Roth s.n.* (G-Bs, iso.).

***Colchicum schimperianum* (Hochst.) C.Archer, non *C. schimper* Janka:117 (1882), comb. nov.**

Androcymbium schimperianum (Hochst.) K.Perss. & Del Hoyo in Botanische Jahrbücher 127: 228 (2007). *Merendera schimperiana* Hochst.: 1126 (1842). Lectotype (designated by Persson & Del Hoyo 2007: 228): Ethiopia, Begemdir, 'In montanis inter Enschedap et Schoata, 2000 ped. infra Enschedap', 4.12.1838, *Schimper* 1126 (P,

holo.; BR, G, K, M, P, iso.) [images of all types (excepting G) observed on website: <http://www.aluka.org>, accessed 21.02.2008].

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APOCYNACEAE

A NEW SPECIES OF HUERNIA (ASCLEPIADOIDEAE–CEROPEGIEAE) FROM ANGOLA

The genus *Huernia* R.Br. consists of 50 species (Bruyns 2007), so that the present new species brings this number to 51. *Huernia* is widely distributed in sub-Saharan Africa and six species also occur in the Arabian Peninsula, as far east as the former Peoples' Democratic Republic of Yemen (South Yemen). In Angola, *Huernia* is represented by *H. calosticta* Bruyns, *H. lopanthera* Bruyns, *H. oculata* N.E.Br., *H. similis* N.E.Br., *H. urceolata* L.C.Leach, *H. verekeri* Stent and *H. volkartii* Peitsch. ex Werderm. & Peitsch. Of these, *H. calosticta*, *H. lopanthera* and *H. similis* are endemic to Angola, whereas *H. oculata* and *H. urceolata* are found in both Angola and Namibia and *H. verekeri* and *H. volkartii* are more widely distributed in southern Africa, from Angola to Mozambique (Bruyns 2005). The new species described here is from the central coastal parts between Lucira and Benguela, beyond the limits of the Namib Desert.

With seven species, *Huernia* is the largest genus among the stapeliads in Angola. So far, apart from the

seven species of *Huernia*, *Australluma peschii*, *Duvalia polita*, *Hoodia currorii*, *H. mossamedensis*, *H. parviflora*, *H. pedicellata*, *Orbea huillensis*, *O. lutea*, *O. maculata*, *Stapelia kwebensis*, *S. parvula*, *S. schinzii*, *Tavaresia angolensis*, *T. barklyi* and *T. thompsoniorum* are the other 15 stapeliads that are known in Angola (Bruyns 2005 and more recent new records).

***Huernia calosticta* Bruyns, sp. nov.**, *H. oculata* similissima sed cum corolla latiora, maculata marronina et papillis longioribus, corona interiore latiore et praesentia tuberculi nectarei differt.

TYPE.—Angola, north of Lucira, 600 m, *Bruyns* 10733 (BOL, holo.; E, iso.).

Dwarf succulent, forming clumps up to 200 mm diam. *Stems* 20–200 × 8–20 mm (excluding teeth), erect to spreading, grey-green; tubercles 6–10 mm long, spreading, deltoid, slightly laterally flattened and joined into 5 angles along stem, tapering into slender caducous tooth.

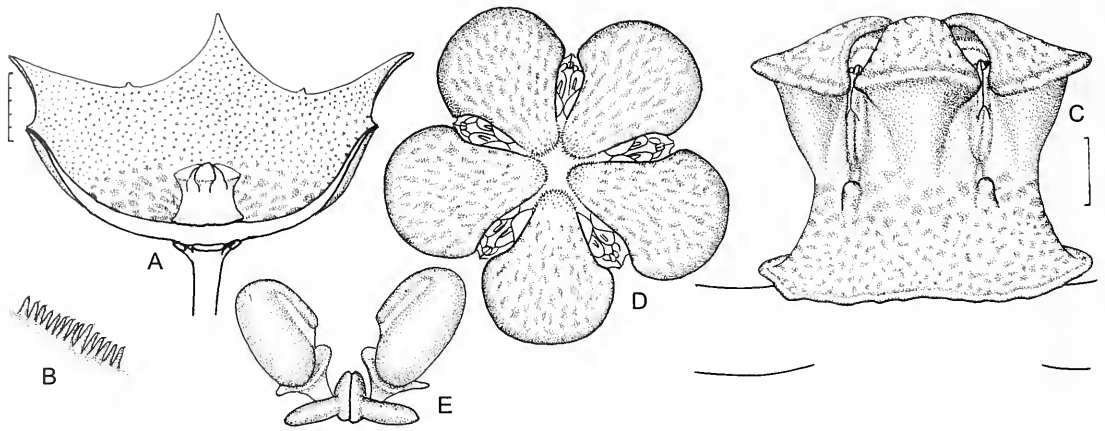


FIGURE 15.—*Huernia calosticta*, Bruyns 10733. A, side view of dissected flower; B, papillae inside corolla from near mouth of tube; C, side view of gynostegium; D, face view of gynostegium; E, pollinarium. Scale bars: A, 5 mm; B, 0.5 mm (at A); C, D, 1 mm (at C); E, 0.25 mm (at C). Artist: P.V. Bruyns.

Inflorescence with several flowers developing in gradual succession from short, stout peduncle, with narrowly attenuate bracts 4–8 mm long at base; pedicel 8–10 × 1.5 mm, spreading and holding flower facing outwards and slightly upwards; sepals 11–12 mm long, 1 mm broad at base, narrowly ovate-attenuate, slightly papillate on exterior. *Corolla* shallowly bowl-shaped, 8–12 × 20–25 mm; outside cream-coloured becoming faintly greenish towards tips of lobes, with small irregular maroon spots becoming smaller towards tips of lobes, covered with low conical and rough papillae, with 4 or 5 raised longitudinal veins

running down from lobes; inside cream-coloured with round dark maroon spots radially elongated around corona and nearly circular further out, spots very fine on lobes and on steep part of tube, larger in flatter part for 5–6 mm around corona, covered with minute, slender, bristly papillae usually tipped with small bristle, papillae usually same colour as background; tube bowl-shaped, ± 7 mm deep, widening from base to mouth; lobes 6 mm long, 12 mm broad at base, broadly deltate, somewhat acuminate, spreading. *Corona* 4 × 5 mm, pale yellow speckled finely with maroon, sessile; outer lobes ± 0.5 mm long, descending to surface of corolla so that apex adpressed to it, ± semicircular-emarginate in outline; inner lobes ± 1.5 mm long, adpressed to backs of anthers, dorsiventrally flattened, with broad transverse dorsal gibbosity ± 2 mm wide at base, beyond anthers descending slightly towards yellow broadly obtuse tips with white bristles. Figure 15.

Huernia calosticta is known from near the coast north of Lucira and from near Catengue, southeast of Benguela (Figure 16). Both of these localities are to the north of and outside the arid Namib region.

Plants occur in bushland dominated by *Acacia*, *Commiphora* and *Adansonia digitata*, often with a few other succulents such as *Ceraria carissoana*, *Pachypodium lealii*, *Stapelia kwebensis*, various species of *Kalanchoe*, *Euphorbia subsalsa* and *Sansevieria cylindrica*. In the vicinity, *Huernia urceolata*, *Stapelia kwebensis* and *Tavaresia angolensis* were observed.

Huernia calosticta is closely allied to *H. oculata* and is vegetatively indistinguishable from it. In *H. calosticta* the corolla faces outwards but slightly upwards, rather than horizontally as in *H. oculata*. Inside, the corolla has dark maroon spots on a cream-coloured background, unlike the alternating pale and dark bands of *H. oculata*. These spots are very fine on the lobes and on the steep part of the tube, becoming abruptly broader on the flat-tened base of the tube for a radius of 5–6 mm around the corona. The inside of

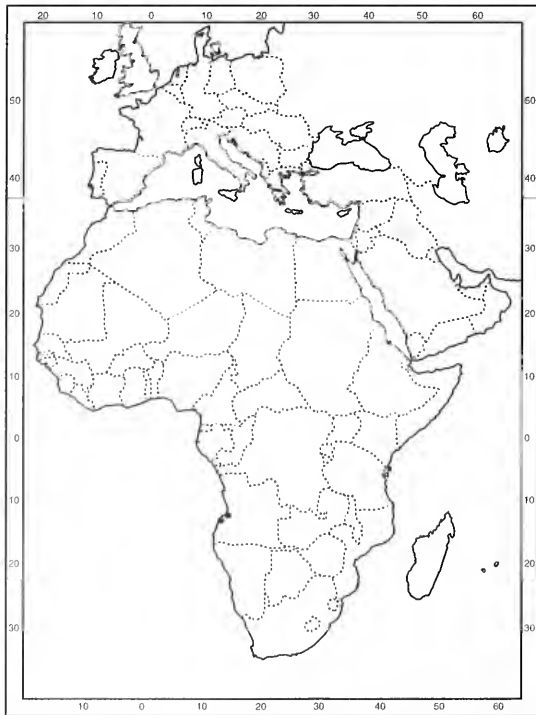


FIGURE 16.—Known distribution of *Huernia calosticta*.

the corolla is covered with fine papillae which are \pm twice the length of those in *H. oculata*.

The corona is broader in *Huernia calosticta* than in *H. oculata* and lacks the very slight stipe found at the base in *H. oculata*. While the outer corona lobes are similar in both, the two differ in the inner corona lobes. In *H. calosticta* the inner lobes are broader, rising slightly over the anthers and then descending towards their apices, rather than rising up well above the style apex as in *H. oculata*. The inner corona lobes have especially broad dorsal gibbositities, that are \pm twice as broad as those in *H. oculata*. Another difference is the presence here of a fairly conspicuous, erect tubercle beneath each guide-rail, a feature absent in *H. oculata*.

Other material examined

ANGOLA.—Near Catengue, SE of Benguela, 780 m, *Bruyns 10756* (BOL).

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ASTERACEAE

TRIPTERIS CALCICOLA. A NEW CALCIPHILIOUS SPECIES FROM WESTERN CAPE, SOUTH AFRICA

The small tribe Calenduleae of the family Asteraceae is centred in southern Africa, where it is concentrated in the winter rainfall parts of the Western and Northern Cape Provinces of South Africa. About 110–120 species are known, currently distributed among 12 genera (Nordenstam 2006, 2007), but the generic limits and relationships within the tribe are still far from completely resolved. The last revision of the southern African species recognized the six genera *Castalis* Cass., *Chrysanthemoides* Fabr., *Dimorphotheca* Vaill. ex Moench., *Garuleum* Cass., *Gibbaria* Cass. and *Osteospermum* L. (Norlindh 1943). The largest of these, *Osteospermum*, was divided on the basis of cypsela morphology into subgenus *Osteospermum*, with 12 sections, and subgenus *Tripteris* (Less.) T.Norl., with three sections (Norlindh 1943). Following a morphological cladistic analysis of the tribe, the genus *Castalis* was included in *Dimorphotheca* along with *Osteospermum* sect. *Blaxium* (Cass.) T.Norl.; and *Osteospermum* subgenus *Tripteris* and *O.* section *Oligocarpus* (Less.) T.Norl. were each recognized at generic level as *Tripteris* Less. and *Oligocarpus* Less. respectively (Nordenstam 1994a, b). As a result of these adjustments, the tribe Calenduleae then comprised the eight genera *Calendula* L., *Chrysanthemoides*, *Dimorphotheca*, *Garuleum*, *Gibbaria*, *Oligocarpus*, *Osteospermum* and *Tripteris*.

This treatment remained current until recently, when analysis of DNA sequence data suggested that several of the genera were paraphyletic as circumscribed. As a result, the circumscriptions of some of the genera were substantially narrowed in an attempt to define them as monophyletic lineages (Nordenstam 2006; Nordenstam *et al.* 2006). The species *Gibbaria ilicifolia* was segregated as the new monospecific genus *Nephrotheca* B.Nord. & Källersjö, and the following elements were removed from *Osteospermum* and *Tripteris* into new or existing genera: the two species of *Tripteris* sect. *Unifenestrata* T.Norl. were transferred to the new genus *Nephrotheca*; the new genus *Norlindhia* B.Nord. was erected to accommodate the two species of *Tripteris* sect.

Efenestrata T.Norl. subsect. *Confusa* T.Norl. plus a third, newly described species, *N. aptera* B.Nord. (Nordenstam 2006); the new genus *Monoculus* B.Nord. was described for the two species previously placed in *Tripteris* sect. *Unifenestrata*; the monotypic genus *Inuloides* B.Nord. was described for the single species of *Tripteris* sect. *Efenestrata* subsect. *Tomentosa* T.Norl.; and a single species of *Osteospermum* was transferred to each of the genera *Dimorphotheca* and *Oligocarpus*.

Currently, therefore, the tribe Calenduleae comprises the genera *Calendula* (\pm 15 spp.), *Chrysanthemoides* (2 spp.), *Dimorphotheca* (20 spp.), *Garuleum* (8 spp.), *Gibbaria* (1 sp.), *Inuloides* (1 sp.), *Monoculus* (2 spp.), *Nephrotheca* (1 sp.), *Norlindhia* (3 spp.), *Oligocarpus* (2 spp.), *Osteospermum* (\pm 45 spp.) and *Tripteris* (20 spp.) (Nordenstam 2007). Despite these taxonomic adjustments, the genus *Osteospermum* is still evidently paraphyletic as currently circumscribed (Nordenstam *et al.* 2006). The distinction between *Osteospermum* and *Chrysanthemoides* in particular has been blurred by the discovery of a species that is intermediate between them in cypsela morphology (Wood & Nordenstam 2003).

Few synapomorphies are available for the recognition of most of these new segregates, several of which are mono- or oligotypic. It is clear that additional genera will need to be recognized as further taxa are included in a molecular analysis if this treatment is to be carried to its logical conclusion (Nordenstam 2007). An alternative, and in our opinion a more useful treatment, is to adopt a synthetic view of the genus *Osteospermum* as constituting the monophyletic clade sister to the genus *Dimorphotheca* as resolved in the phylogenetic analysis reproduced by Nordenstam *et al.* (2006), thus including the genera *Calendula*, *Chrysanthemoides*, *Gibbaria*, *Inuloides*, *Monoculus*, *Nephrotheca*, *Norlindhia*, *Oligocarpus* and *Tripteris*. In this circumscription the two genera *Dimorphotheca* and *Osteospermum* are separated from *Garuleum* by the synapomorphy of a shortly bilobed style with an annular collar of hairs in the disc florets, and are in turn distinguished from one another by

several morphological, micromorphological and chemical characters: *Dimorphotheca* by large flower heads with ray florets more than twice as long as the involucre, \pm uniseriate involucre, ray florets that are white, orange or purple (rarely pure yellow) and flushed dark beneath, fertile or functionally male disc florets, uniseriate corolla hairs, and the presence of dimorphecolic acid; and *Osteospermum* by the smaller flower heads with ray florets usually up to twice as long as the involucre, mostly bi- or triseriate involucre, yellow or orange-yellow ray florets, functionally male disc florets, biseriate corolla hairs, and the presence of significant quantities of calendic acid (Nordenstam 1994b).

Until a complete classification of the tribe is available, however, we follow current practice and describe the following new species in the genus *Tripteris* s. str. (Nordenstam 2006), with which it accords in its 3-winged cypselae with the apical air chamber enclosed by three translucent windows. In this narrow sense, *Tripteris* comprises \pm 20 species of perennial (rarely annual) herbs, subshrubs or shrubs that are widely distributed through Africa, with about half the species occurring in the winter rainfall parts of South Africa and southern Namibia. An attractive new species from coastal limestone outcrops at Jacobsbaai on the Saldanha Peninsula in the Western Cape represents the first limestone endemic in the genus, which we describe here as *T. calcicola*.

***Tripteris calcicola* J.C.Manning & Goldblatt, sp. nov.**

Herba multicaulis perennis, caulibus florentibus 200–300 mm altis *Tripteris aghillanae* affinis sed ab ea habitu rhizomatoso (non suffrutex pulviniformis), rhizomate multiramato lignoso \pm 5 mm diam., foliis latioribus 30–40 mm (non 5–20 mm) latis, bracteis involucribus \pm 20 (non 12 ad 15) atque flosculis radiati involucri \pm triplo (non duplo) longioribus distinguitur.

TYPE.—Western Cape: 3217 (Vredenburg); Jacobsbaai, inland of Mauritzbaai, limestone outcrops, (–DD), 15 August 2007, Manning 3100 (NBG, holo.; MO, iso.).

Multi-stemmed, rhizomatous perennial, 200–300 mm high; rhizome much-branched, \pm 5 mm diam., producing clusters of tufted shoots that elongate the following year and flower before dying down; stems suberect, sparsely branched, nodding in fruit, glabrous on first season's growth but densely glandular-pubescent on second season's growth, pale green with glandular heads of trichomes purple. Leaves alternate throughout, congested basally, erect, decreasing in size acropetally, lower leaves broadly obovate to oblanceolate, tapering below into long, petiole-like base, midrib prominent abaxially, petiole 35–45 mm long; blade 30–40 \times 20–30 mm, leathery, puberulous with glandular and eglandular trichomes, these longer along margins, margins sparsely and weakly \pm 10-dentate, subobtusely-mucronulate, upper leaves oblong-lanceolate, 10–20 \times (3–)5–7 mm. Capitula heterogamous, radiate, \pm 60 mm diam., solitary on shortly leafy, peduncle-like stems. Involucre shallowly campanulate, 10–12 mm diam.; involucrial bracts \pm 20, uniseriate, lanceolate, 6–7 \times 2–3 mm, acute, densely glandular-pubescent, glandular heads of trichomes purple,

with scarious margins 0.5–1.0 mm wide. Receptacle flat, glabrous. Ray florets female-fertile, 20–22; tube sparsely glandular-pubescent, \pm 0.8 mm long, up to 9 setting fruit; lamina spreading but recoiling in afternoon, narrowly elliptic, 4-veined, \pm 3 \times as long as involucre, 20–25 \times 4–5 mm, straw-yellow marked with dark maroon adaxially in basal 5–6 mm, flushed reddish abaxially, veins red. Anthers vestigial, free, reduced to 4, subulate staminodes \pm 0.8 mm long, yellow. Style terete, on short stylopodium, branching \pm 1 mm above mouth of tube, branches narrowly elliptic-lanceolate, obtuse, \pm 1.5 mm long, yellow, lateral margins stigmatic. Ovary obovoid, 3-angled, \pm 2 mm long, shortly glandular-pubescent. Cypselae homomorphic, 3-winged, 10–12 \times 7 mm, body narrowly turbinate, \pm 6 mm long, glandular-pubescent, with apical, trifenestrate airchamber, windows ovate, 3.5 \times 2.0 mm, wings translucent, \pm 2.5 mm wide. Disc florets functionally male, numerous; corolla narrowly funnel-shaped, 4–5 mm long, yellow; tube glandular-hairy, \pm 3 mm long; lobes suberect, triangular, \pm 2 mm long, with marginal veins joining at sinuses and continuing down tube. Anthers 2 mm long, dark purple with yellow filaments; anther base tailed, tails equalling filament collar; anther appendage ovate. Ovary compressed-ovoid with lateral ribs, \pm 1 mm long, glandular-pubescent. Style terete, on short stylopodium, shortly bilobed apically, lobes deltoid, acutely papillate with basal fringe of longer trichomes. Flowering time: August. Figure 17.

Distribution and ecology: so far known only from the vicinity of Jacobsbaai just north of Saldanha Bay on the west coast of the Western Cape (Figure 18), the species is a component of Saldanha Limestone Strandveld (Mucina & Rutherford 2006), a rare coastal vegetation type that is almost entirely limited to the Saldanha Peninsula and is rich in Red Data species. Plants of *Tripteris calcicola* are restricted to exposed outcrops of limestone, where they grow in shallow, loamy soils overlying limestone pavement. Co-occurring endemic shrublets include *Diosma* cf. *guthriei* (Rutaceae), *Felicia elongata* (Asteraceae) and *Nenax hirta* subsp. *calciphila* (Rubiaceae).

The woody rhizomes of *Tripteris calcicola* creep along the surface of the rock through the shallow soil layer, sending up numerous aerial shoots with tufts of leaves during the growing season. These shoots do not die back during the ensuing summer but elongate over the second growing season during the winter, and flower in the early spring before dying back completely after fruiting. This distinctive growth form results in a single ramet spreading over an area of one or two square metres, producing numerous, tufted shoots each year plus several suberect flowering stems. The flower heads expand fully during the mid-morning but the ray florets curl back by mid-afternoon. The flower heads have a remarkable similarity in size, colour and marking to the local form of *Ursinia anthemoides* (for illustration see Manning 2003: 256).

Diagnosis and relationships: the large, 3-winged cypselae with 3-windowed apical air chambers place this species among those treated as *Osteospermum* subgenus *Tripteris* section *Trifenestrata* by Norlin (1943) and as the genus *Tripteris* s. str. by Nordenstam (1994a). Among these species it appears to be most closely allied to *T. aghillana* DC., a cushion-forming subshrub with

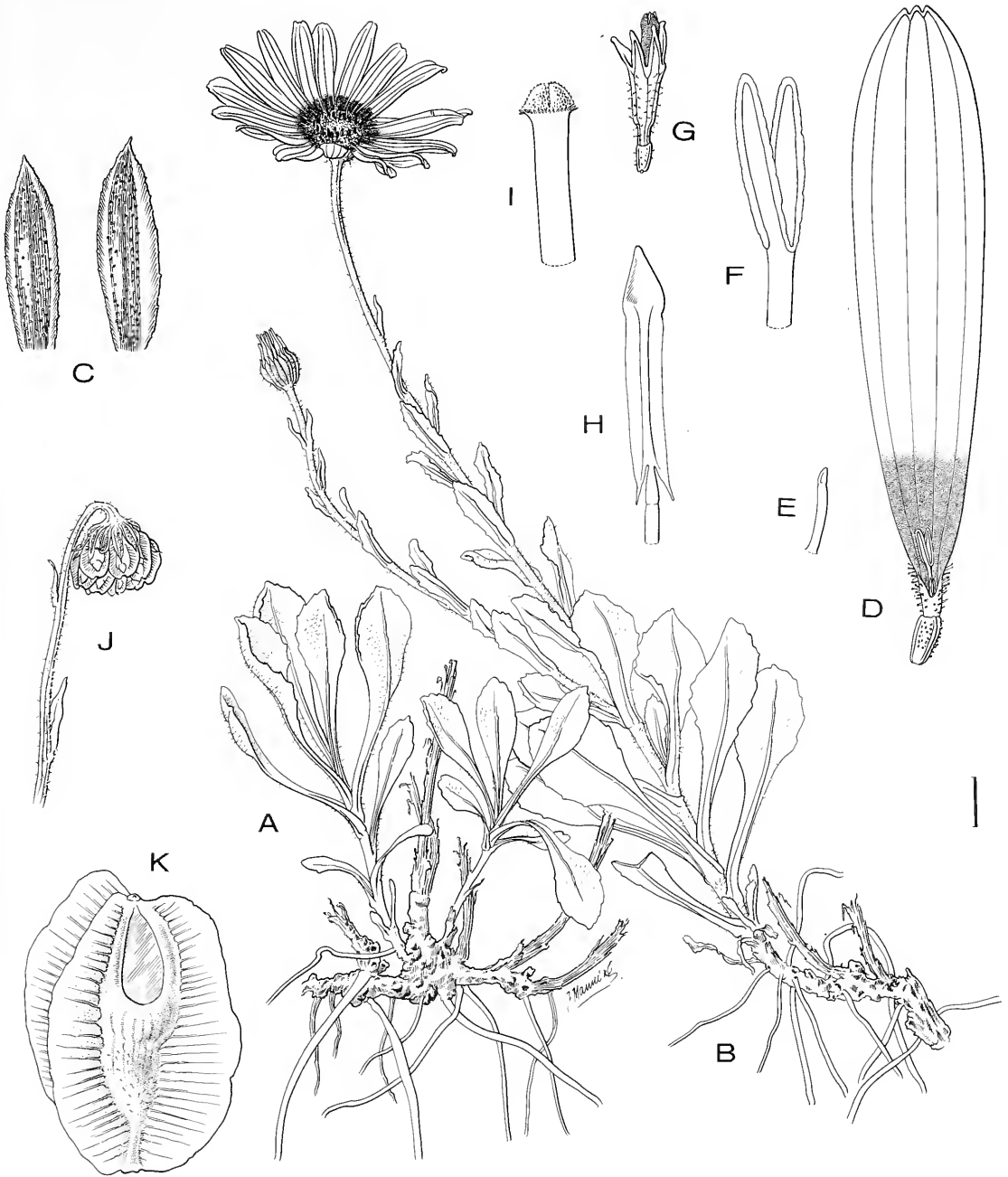


FIGURE 17.—*Tripteris calcicola*, Manning 3100 (NBG). A, vegetative shoots; B, flowering shoot; C, involucre bracts. D–F, details of ray floret: D, floret; E, staminode; F, style branches. G–I, disc floret: G, floret; H, single anther; I, style branches. J, fruiting head; K, cypselae. Scale bars: A, B, J, 10 mm; C, 1.5 mm; D, G, K, 2 mm; E, F, H, I, 0.5 mm. Artist: J. Manning.

large, homomorphic cypselae, basally congested leaves, and large flower heads in which the ray florets are strongly marked at the base with dark purple bands and the anther appendages at least are also dark purple. Ray florets with dark bases are known elsewhere in the subgenus only in the somewhat distantly related *Monoculus monstrosus* (Burm.f.) B.Nord. (= *Tripteris clandestina* Less.), an annual species placed in *Osteospermum* subgenus *Tripteris* section *Unifenestrata* by Norlindh (1943). *T. calcicola* differs from *T. aghillana* in distri-

bution, ecology, habit and morphology. *T. aghillana* is widespread through the interior of the Western Cape, reaching the coast only at Cape Agulhas, and although also a subshrub with annual flowering stems, it is not rhizomatous, and the persistent woody bases of the stems are carried above ground so that the plant develops a rounded, cushion-like habit. This is in contrast to the subterranean woody rhizomes of *T. calcicola*, in which only the leafy shoots project above the soil surface and the plant develops a creeping, mat-like habit. *T. calcicola*

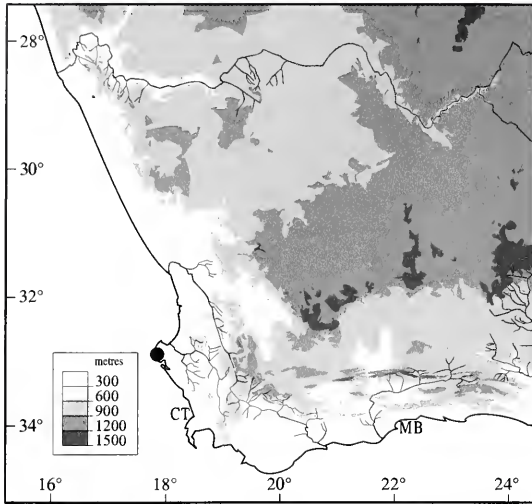


FIGURE 18.—Known distribution of *Tripteris calcicola*.

is further distinguished by its broader leaves, 30–40 mm wide vs 5–20 mm; more numerous involucre bracts, ± 20 vs 12–15; and longer ray florets, \pm three times as long as the involucre vs \pm twice as long.

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which was made under a permit from Cape Nature, and Roy Gereau kindly provided the Latin diagnosis.

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Vegetation and vegetation-environment relationships at Grootbos Nature Reserve, Western Cape, South Africa

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Keywords: Afromontane Forest, Agulhas Plain, biodiversity, CCA, fynbos, GIS, Milkwood Scrub Forest, numerical vegetation analysis, TWINSPLAN, Western Cape

ABSTRACT

The private Grootbos Nature Reserve is located at the Western edge of the Agulhas Plain in the Cape Floristic Region of South Africa, an area characterized by high habitat and floristic diversity. The Reserve is covered in near-natural fynbos shrublands with a few patches of forest and wetland. The main objective of this study was to classify the vegetation into discrete units and relate them to the prevailing environmental conditions. The vegetation was analysed by numerical means (TWINSPLAN, DCA, CCA) and mapped on GIS. At the vegetation type level, Forest & Thicket and Fynbos formed distinctive clusters, whereas the wetland relevés were intermixed, but without relationships to one of these units. Fire incidence served as the major determinant of the forest-fynbos boundary. The Forest & Thicket grouping was separated into Thicket (as transitional to fynbos), Afromontane Forest and Milkwood Scrub Forest. Two broad complexes were distinguished within the Fynbos grouping, the Alkaline Sand Fynbos Complex corresponding to Coastal Fynbos, and the Acid Sand Fynbos Complex corresponding to Mountain Fynbos. They discriminated along gradients of pH, soil depth and rock cover. The complexes were further subdivided into formations by using one or a few subjectively chosen dominant species as indicators. The transitions between these formations were rather continuous than discrete. The vegetation type and complex levels correspond well to existing fynbos-wide classifications. Comparing the formations to the results of other vegetation studies is problematic even on the scale of the Agulhas Plain, due to the high regional plant diversity in the Fynbos Biome.

INTRODUCTION

An important, and well-established aspect of the species-rich Cape flora is the difficulty in resolving regional vegetation associations into meaningful, easily identifiable floristic groupings (Campbell 1986). Various authors have tried to classify the habitat types and the plant communities of the Fynbos Biome in the previous decades, some looking at broad descriptions of major vegetation types (Taylor 1978; Moll *et al.* 1984; Campbell 1985; Cowling & Hejnis 2001) and others at detailed descriptions of communities (McKenzie *et al.* 1977; Boucher 1978; Taylor 1983; Richards *et al.* 1995; Cowling *et al.* 1996; McDonald *et al.* 1996; Taylor 1996). The Agulhas Plain, covering an area of 270 000 hectares of semi-arid lowland fynbos and renosterveld, has been prioritized as an area of high irreplacability and high vulnerability, with exceptionally rich coastal lowland ecosystems (Cowling *et al.* 1999). Cowling *et al.* (1988) applied the mountain vegetation classification approach of Campbell (1985) to the Agulhas Plain. This classification was produced using the Braun-Blanquet method of table sorting and was based on structural and higher taxon characteristics of the vegetation. Nine zonal communities, at various hierarchical levels, were recognized and mapped. This phytosociological approach provided a qualitative description of community environmental characteristics on the Agulhas Plain. The only study on the Agulhas Plain to provide a quantitative assessment of the importance of environmental factors was Richards *et al.* (1995) who explored vegetation-environment rela-

tionships in a 30 ha study area, the Soetanysberg, \pm 15 km west of Cape Agulhas (34°45' S; 19°50' E). However, no comparable studies have been undertaken on the west side of the Agulhas Plain.

The major objective of this study was to fill this gap through a detailed mapping and numerical analysis of the vegetation of Grootbos Nature Reserve (GNR), which is located at the western edge of the Agulhas Plain, between the villages of Stanford and Gansbaai (Figure 1A). The geographic coordinates are 34°32'30" S and 19°24'50" E. The privately owned reserve consists of seven formerly separate farms covering an area of 1 700 ha. It is run as an upmarket ecotourism lodge. The landscape is sloping, with a maximum elevation of \pm 475 m along the slopes of the Swartkransberg (Figure 1B). The underlying rock type of the more elevated hills is quartzitic Table Mountain Sandstone. On the lower slopes, deposits of sandy aeolian material overlay the bedrock. Outcrops of the Bredasdorp Limestone are exposed in some places.

The climate, which can be characterized as maritime mediterranean, shows a strong seasonality in precipitation. May to August are the wettest months (most precipitation is carried by northwesterly winds), whereas the southeasterly winds prevailing in the summer months are dry. There has been no long-term precipitation record at GNR. The mean annual rainfall from 1996–1998 was 730 mm. The mean maximum daily temperatures fluctuate between 25°C in February and 14°C in July. The GNR is frost-free.

Since 1995 the property has been managed for conservation and ecotourism. Over the last decade a team of botanists has been actively sampling and collecting plant specimens over the entire reserve. At the latest count, 660 species of indigenous plants have been recorded on the property, with still more being found

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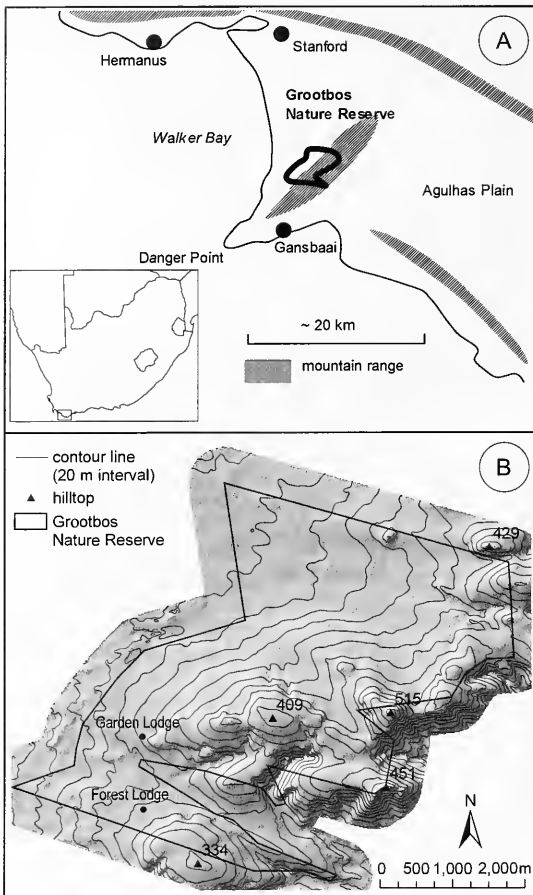


FIGURE 1.—A, study area located between Cape Town and Cape Agulhas, 5 km east of Walker Bay seashore; B, western part of Grootbos Nature Reserve gently sloping towards Walker Bay, eastern part hilly with maximum elevation slightly below 500 m.

each year (Privett & Lutzeyer in press). Fifty-one species are included in the Red Data List of threatened species (Hilton-Taylor 1996), and three species (*Erica magnisylvae*, *Cliffortia anthospermoides*, *Lachenalia lutzeyerii*) were recently discovered and are considered endemic to the Reserve. The vegetation of GNR, largely fynbos shrubland with some patches of forest and wetland, is amongst the best surveyed in the Cape Floristic Region and lends itself to a detailed quantitative analysis of vegetation-environment relationships.

METHODS

Data collection

Vegetation sampling at GNR was carried out in winter 1997 and in spring 2004. Seventy-one 50 m² (10 × 5 m) rectangular relevés were analysed for their floristic composition and their major environmental features. They were subjectively chosen in order to represent homogeneous patches of vegetation and divided into 10 cells, 2.0 × 2.5 m each. The floristic composition was investigated for each cell, including all identifiable species. All

taxonomy followed Goldblatt & Manning (2000). The cover was recorded as a percentage. Soil samples were taken at random localities within each relevé, in depths of 5–30 cm depending on soil depth. Environmental data were recorded for each relevé: topographic parameters (slope, elevation, aspect), vegetation age, soil depth, rock cover, pH, resistance and nutrient levels of the soil. Flow accumulation (wetness index), solar radiation and the exposure to the fire-bearing southeasterly winds were computed from a digital elevation model (DEM). All relevés were used for analysis, including those located in transitional vegetation. The GPS coordinates of each relevé were stored and the southwestern corner was marked with a concrete lintil or an iron peg to enable further monitoring.

In addition to the regular relevés (core dataset), 127 sites were analysed to a lesser extent (these and the core dataset together are referred to as the extended dataset). This was done without setting up a formal plot and only the dominant and easily identifiable species were recorded. The coordinates were located with a GPS and stored for mapping. No environmental data were taken directly for these additional relevés, but the parameters extracted from the DEM were stored.

Numerical vegetation analysis

A classification and certain ordinations were applied to the sampled dataset. The classification was performed using TWINSpan (Hill 1994). For the classification of the core dataset, the pseudospecies cut levels were set to 0, 5, 10, 20 and 50, for the extended dataset to 0, 2, 5, 10, 20, 50. The first pseudospecies of the extended dataset was excluded from the classification. Splitting was allowed down to two species (default: five) for both datasets. An indirect ordination (Detrended Correspondence Analysis, DCA) was performed for the extended dataset. A direct ordination (Canonical Correspondence Analysis, CCA) was applied to the core dataset (due to the availability of environmental data). Both ordinations were run with the whole dataset and then repeated only including relevés classified as Fynbos. The default parameters suggested by the programs (DECORANA for the DCA and MVSP for the CCA) were applied to the analyses.

Vegetation mapping

A set of colour orthophotos (spatial resolution: 0.75 m) as well as a GIS dataset representing preliminary vegetation units mapped in 1997 were available. Attempts to extract vegetation units from the imagery by numerical means failed as the different fynbos types showed very similar reflection properties, while the reflection properties varied very much within each type. Consequently, GNR was explored during several excursions and assessed according to the subjective impression of the authors, supported by the relevé information. In addition, a large number of localities were recorded by GPS in order to locate the transitions between vegetation units. All the point data were transferred to a GIS and mapped onto the composite orthophoto. The information provided by the orthophotos was combined with the point data, the results of the numerical vegetation analysis and the existing GIS dataset to generate a comprehensive map of meaningful vegetation units.

RESULTS

Numerical vegetation analysis

The TWINSPLAN classification clearly supported the presence of two major vegetation types on GNR: one fynbos (Cape Fynbos Shrublands) and the other non-fynbos (Forest & Thicket). The wetland relevés were not clearly assigned to any of these groups, and as a result were considered as an independent vegetation type. The Fynbos grouping was further split into an Acid Sand Fynbos Complex and Alkaline Sand Fynbos Complex, the Forest & Thicket grouping in Milkwood Scrub Forest, Afromontane Forest and Thicket. No further significant splitting was possible in the wetland grouping.

The level of vegetation complexes was the maximum of detail supported by the classification. However, for the fynbos, some smaller units were clearly recognizable in the field, mostly dominated by a few or even only one species and with the bulk of the species shared among all the units of the corresponding complex. These detailed units were conceptualized as formations, which are summarized in Table 1.

The ordination results corresponded well to the classification results. In the DCA for the extended dataset, Afromontane Forest, Milkwood Scrub Forest and Fynbos were clearly separated along the first axis (eigenvalue = 0.91), with the Thicket and the Wetland relevés intermediate between Milkwood Scrub Forest and Fynbos (Figure 2A). The two fynbos complexes were discriminated along the second axis (eigenvalue = 0.65). The DCA only including the relevés classified as fynbos (Figure 2B; eigenvalues: 0.68 for the first axis and 0.62 for the second axis) showed a clear clustering of some formations established in the classification (*Thamnochortus fraternus* Restioid Fynbos, *Erica sessiliflora* Ericaceous Fynbos) and the post-fire relevés of *Protea repens* Proteoid Fynbos. The transitions between the remaining formations appeared to be highly continuous.

The CCA (Figure 3A) illustrated the clear and discrete discrimination of Fynbos and Forest depending on vegetation age, which was almost coincident with the first axis (for eigenvalues and canonical coefficients compare Table 2). The forest complexes were discriminated by elevation, slope, aspect and certain soil characteristics. The fynbos relevés were aligned continuously along the second axis, discriminated by gradients of elevation, slope, pH, soil depth and rock cover. The Alkaline Sand Fynbos Complex and the Acid Sand Fynbos Complex were clearly recognizable, but closely together. The exclusion of all non-fynbos relevés from the CCA (Figure 3B) did not lead to a clearer distinction of these clusters. No clear structure was recognizable within the two subclusters either. Only the *Thamnochortus fraternus* Restioid Fynbos and the *Protea repens* Proteoid Fynbos formed \pm proper clusters. A number of environmental variables showed similar explanatory value. In addition to the site scores, the scores of selected species were plotted (Figure 4). The species were grouped in the same manner as the relevés they dominate. The red data species appear to be associated with rather extreme conditions as they occupy the edges of the plot.

*Vegetation units**Afromontane Forest*

Five patches of Afromontane Forest are present at the GNR, all of them situated in the forest valley (Figure 5A). The CCA suggested an association with shallow, neutral to slightly acid soils rich in K and Mg. The relief is characterized by steep slopes protected from the southeasterly winds. Afromontane Forests form tall canopies with heights of more than 10 m. The canopy is frequently dominated by *Rapanea melanophloeos*. The well-developed subcanopy is 3–10 m high, comprising *Celtis africana*, *Chionanthus foveolatus*, *Diospyros whyteana*, *Kiggelaria africana* and *Sideroxylon inerme*. Most of these species have the potential to grow to canopy height. Due to the dark interior of the forest, the ground layer is usually sparse with *Asplenium adiantum-nigrum*, *Droguetia iners* and *Ehrharta erecta* as the most common species. Climbers are present (*Asparagus aethiopicus*, *A. scandens* and *Cynanchum obtusifolium*). The species diversity is low at the 50 m² level, averaging 13.2 identifiable species per relevé.

The range of temperate forest ecosystems referred to as Afromontane Forest includes the mountains of the southern Cape but stretches far into tropical Africa where they occur at higher altitudes (Midgley *et al.* 1997). The Afromontane Forests of the Agulhas Plain are ecologically similar but floristically distinct from those considered by Campbell (1985). Instead they show affinities to the dune forests of the Tongaland-Pondoland Forest (Moll & White 1978). These forests, and also the Afromontane Forest along the south coast (Knysna, Tsitsikamma), have significantly higher species diversities than the forests on the GNR. They host taxa not present on GNR, such as Podocarpaceae and Cyatheaceae. One reason for the declining diversity towards the southwest may be that more and more species disappear as the climatic conditions become harsher and the forest patches smaller.

Milkwood Scrub Forest

Four patches of Milkwood Scrub Forest are present at low elevations, associated with deep, slightly acid to alkaline, sandy, colluvial soils with high contents of Ca and P. In contrast to the Afromontane Forest, the CCA did not indicate a negative spatial coincidence with the southeasterly winds. The high levels of mineral components appear to be a distinctive feature of this type of ecosystem. Ca in particular is considerably richer in the forest than anywhere else on the GNR. In addition, the soils are very fertile due to plant-induced organic enrichment (Thwaites & Cowling 1988), which makes them suitable for agriculture and thus susceptible to anthropogenic disturbance.

A single tree layer, usually dominated by *Sideroxylon inerme*, attains a height of 6 m and a very dense cover. *Euclea racemosa* does form part of the canopy in some places, whereas *Chionanthus foveolatus*, *Gymnosporia buxifolia* and the winter-deciduous *Celtis africana* occur as single trees or small groups. The soil is covered by a 50–300 mm high, sparse to dense (where sufficient light is available) herb layer dominated by *Droguetia iners* and *Ehrharta erecta*. The only shrub species in the full

TABLE 1.—Summary of vegetation units recognized in this study. Average species numbers of complexes on 50 m² level in brackets

Vegetation unit	Diagnostic spp.	Common species	Average value		
			a	b	c
Milkwood Scrub Forest (11.0)		<i>Sideroxylon inerme</i> , <i>Euclea racemosa</i> , <i>Myrsine africana</i> , <i>Cynanchum obtusifolium</i> , <i>Asparagus aethiopicus</i> , <i>Droguetia iners</i> , <i>Ehrharta erecta</i>	246	91	7.2
Afromontane Forest (13.2)		<i>Rapanea melanophloeos</i> , <i>Kiggelaria africana</i> , <i>Diospyros whyteana</i> , <i>Celtis africana</i> , <i>Chionanthus foveolatus</i> , <i>Droguetia iners</i> , <i>Asparagus scandens</i> , <i>Asplenium adiantum-nigrum</i>	308	34	6.7
Thicket Complex (ND)			ND	ND	ND
True Thicket	< 3: <i>Pteris dentata</i>	<i>Euclea racemosa</i> , <i>Salvia africana-lutea</i> , <i>Myrsine africana</i> , <i>Nylandtia spinosa</i> , <i>Gymnosporia buxifolia</i> , <i>Leucadendron confierum</i> , <i>Thamnochortus erectus</i> , <i>Sideroxylon inerme</i>	ND	ND	ND
<i>Pteris dentata</i> Shrubland	> 2: <i>Pteris dentata</i>	<i>Pteris dentata</i> , <i>Leucadendron confierum</i> , <i>Myrsine africana</i> , <i>Diospyros whyteana</i>	ND	ND	ND
Wetland Complex (9.3)			272	100	6.8
TWINSPAN indicator: <i>Mariscus thunbergii</i>					
True Wetland	< 3: <i>Pteris dentata</i>	<i>Mariscus thunbergii</i> , <i>Artemisia afra</i> , <i>Cliffortia ferruginea</i> , <i>Psoralea arborea</i> , <i>Ischyrolepis eleocharis</i> , <i>Zantedeschia aethiopica</i> , <i>Gunnera perpensa</i> , <i>Hippia frutescens</i> , <i>Helichrysium cymosum</i> subsp. <i>cymosum</i> , <i>Leonotis leonurus</i>	291	100	7.1
<i>Pteris dentata</i> Fernland	> 2: <i>Pteris dentata</i>	<i>Pteris dentata</i> , <i>Mariscus thunbergii</i> , <i>Kiggelaria africana</i> , <i>Zantedeschia aethiopica</i> , <i>Diospyros whyteana</i> , <i>Gunnera perpensa</i>	236	100	6.1
Alkaline Sand Fynbos Complex (24.9)			286	62	7.3
Dune Asteraceous Fynbos	< 2: <i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i> , <i>Protea obtusifolia</i> , <i>P. repens</i> , <i>Thamnochortus fratermus</i> ; < 3: <i>Erica coccinea</i> (yellow-flowered variant)	<i>Metalasia muricata</i> , <i>Passerina vulgaris</i> , <i>Euclea racemosa</i> , <i>Erica irregularis</i> , <i>Ischyrolepis eleocharis</i> , <i>Thamnochortus erectus</i> , <i>Otholobium bracteolatum</i> , <i>Anthospermum aethiopicum</i>	255	77	7.7
Neutral Sand Proteoid Fynbos	> 1: <i>Leucadendron confierum</i> or <i>Leucospermum patersonii</i> ; < 3: <i>Erica coccinea</i> (yellow-flowered variant); < 2: <i>Protea obtusifolia</i> , <i>P. repens</i> , <i>Thamnochortus fratermus</i>	<i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i>	335	59	6.5
<i>Protea repens</i> Proteoid Fynbos	> 1: <i>Protea repens</i> ; <i>P. obtusifolia</i> < <i>P. repens</i>	<i>Protea repens</i> , <i>Cliffortia ilicifolia</i> , <i>Willdenowia teres</i> , <i>Phylica disticha</i> , <i>Diosma subulata</i> var. <i>subulata</i> , <i>Passerina vulgaris</i>	326	100	6.0
<i>Protea obtusifolia</i> Proteoid Fynbos	> 1: <i>Protea obtusifolia</i> ; < 2: <i>Thamnochortus fratermus</i> ; <i>P. obtusifolia</i> => <i>Erica coccinea</i> (yellow-flowered variant)	<i>Protea obtusifolia</i> , <i>Erica coccinea</i> (yellow-flowered variant), <i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i>	258	82	7.7
<i>Erica coccinea</i> Ericaceous Fynbos	> 2: <i>Erica coccinea</i> (yellow-flowered variant); < 2: <i>Thamnochortus fratermus</i> ; <i>E. coccinea</i> (yellow-flowered variant) < <i>Protea obtusifolia</i> , <i>Leucadendron confierum</i> and <i>Leucospermum patersonii</i>	<i>Erica coccinea</i> (yellow-flowered variant), <i>Erica irregularis</i> , <i>Cullumia squarrosa</i> , <i>Oedera capensis</i> , <i>Indigofera brachystachya</i>	209	30	8.0
<i>Thamnochortus fratermus</i> Restioid Fynbos	> 1: <i>Thamnochortus fratermus</i>	<i>Thamnochortus fratermus</i> , <i>Erica coccinea</i> (yellow-flowered variant), <i>Protea obtusifolia</i> , <i>Leucadendron confierum</i> , <i>Indigofera brachystachya</i>	323	2	7.3
Acid Sand Fynbos Complex (35.0)			376	28	5.5
TWINSPAN indicators: <i>Mimetes cucullatus</i> , <i>Leucadendron salignum</i> , <i>Erica glabella</i>					
Acid Sand Proteoid Fynbos	< 2: <i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i> , <i>Protea obtusifolia</i> ; < 3: <i>Erica sessiliflora</i> , <i>Elegia thyrsifera</i>	<i>Mimetes cucullatus</i> , <i>Leucadendron salignum</i> , <i>Aulax umbellata</i> , <i>Protea cynaroides</i> , <i>L. xanthocomus</i> , <i>Protea longifolia</i> , <i>Penaea mucronata</i> , <i>Morella quercifolia</i> , <i>Indigofera brachystachya</i> , <i>Elegia juncea</i> , <i>Pseudopentameris macrantha</i> , <i>Bobartia indica</i> , <i>Erica glabella</i> , <i>Trichocephalus stipularis</i>	386	26	5.4
Transitional Proteoid Fynbos	> 1: <i>Leucadendron confierum</i> or <i>Leucospermum patersonii</i> ; <i>Erica sessiliflora</i> , <i>Elegia thyrsifera</i> < <i>L. confierum</i> , <i>L. patersonii</i>	<i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i> , <i>Protea obtusifolia</i> , <i>Mimetes cucullatus</i> , <i>Leucadendron tinctum</i> , <i>L. salignum</i> , <i>Erica glabella</i>	376	40	5.6
<i>Erica sessiliflora</i> Ericaceous Fynbos	> 2: <i>Erica sessiliflora</i> ; <i>E. thyrsifera</i> , <i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i> <= <i>E. sessiliflora</i>	<i>Erica sessiliflora</i> , <i>E. glabella</i> , <i>Leucadendron confierum</i> , <i>Mimetes cucullatus</i> , <i>Leucospermum patersonii</i> , <i>Drosera capensis</i> , <i>Cliffortia ferruginea</i> , <i>Psoralea arborea</i> , <i>Berzelia lanuginosa</i> , <i>Staavia radiata</i>	297	55	5.6
<i>Elegia thyrsifera</i> Restioid Fynbos	> 2: <i>Elegia thyrsifera</i> ; <i>E. thyrsifera</i> => <i>Leucadendron confierum</i> , <i>Leucospermum patersonii</i> ; <i>E. thyrsifera</i> > <i>Erica sessiliflora</i>	<i>Elegia thyrsifera</i> , <i>Helichrysium patulum</i> , <i>Thamnochortus erectus</i> , <i>Morella quercifolia</i> , <i>Leucospermum patersonii</i> , <i>Leucadendron confierum</i> , <i>Erica sessiliflora</i>	ND	ND	ND

a, elevation (m); b, soil depth (cm); c, pH; ND, no data.

Numbers close to diagnostic species: pseudospecies levels of TWINSPAN-classification for extended dataset.

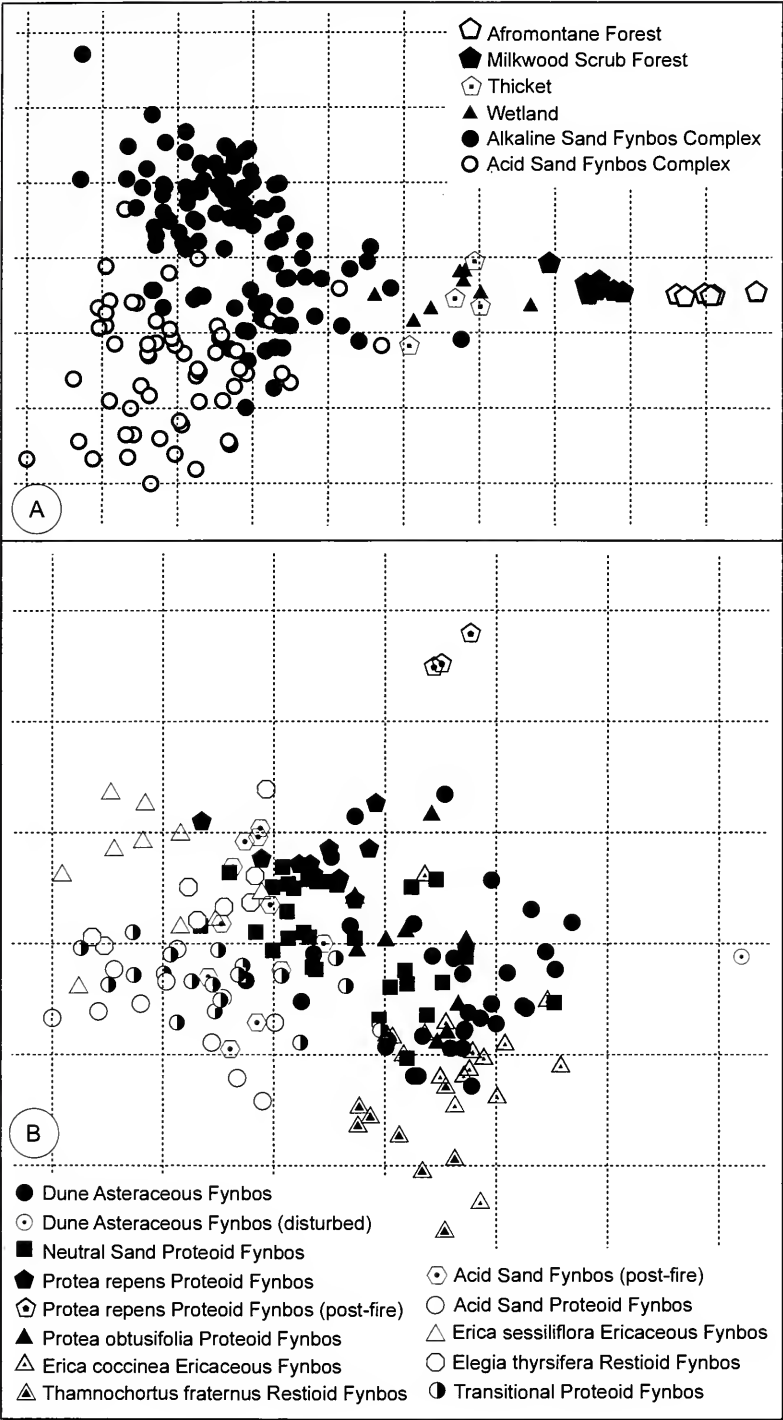


FIGURE 2.—A, Detrended Correspondence Analysis (DCA) for complete extended dataset resulted in clusters of Afromontane Forest, Milkwood Scrub Forest, Alkaline Sand Fynbos Complex and Acid Sand Fynbos Complex; B, DCA for fynbos relevés of extended dataset resulted in discrimination of two fynbos complexes.

shade of the forest is *Myrsine africana*, which may grow higher than 1 m. The abundance of lianas (*Asparagus aethiopicus*, *Cynanchum obtusifolium*) and epiphytes (mainly cryptogams) is considerable. Dead vertical branches of the spiny *A. aethiopicus* are particularly responsible for parts of the forest having a thicket-like character (Figure 5B). The species diversity is low at the 50 m² level, averaging only 11 identifiable species.

Thicket

The fynbos-forest boundary is rarely sharply defined, but is often made up of a thicket of varying height and density. This vegetation unit does not necessarily correspond to the Subtropical Thicket described by Midgley *et al.* (1997), although it may share certain characteristics with it. Thickets are characterized by a mixture of forest and fynbos elements. They occur at sites where

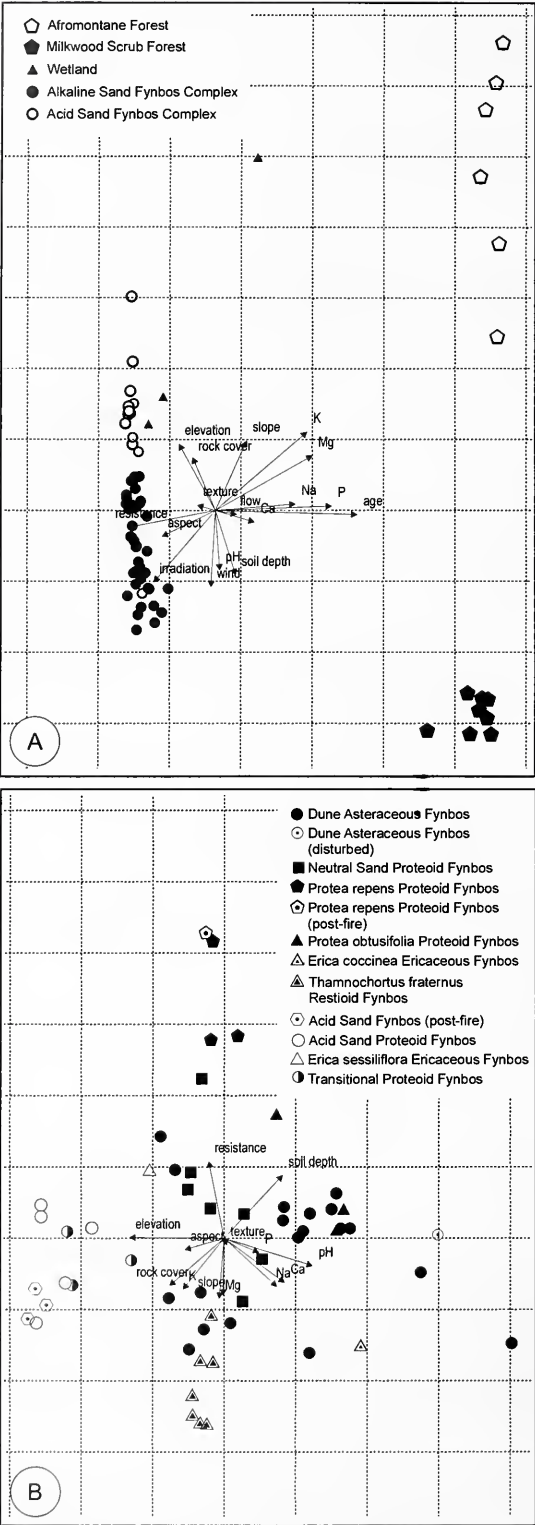


FIGURE 3.—A, results of Canonical Correspondence Analysis (CCA) for entire core dataset indicate clear separation between Fynbos complexes, Afromontane Forest and Milkwood Scrub Forest, whereas Wetland relevés are intermixed; B, results of CCA for fynbos relevés of core dataset show continuous transition between formations.

fire frequency or intensity have been reduced over a certain period, but not sufficiently to support forest: in the buffer zones between fynbos and the Milkwood Scrub Forest, in protected ravines as a successional stage from fynbos to Afromontane Forest and on some south-facing slopes of the forest valley. The latter (adjacent to the Afromontane Forest) is dominated by the fern *Pteris dentata*, which attains a very high cover in these places. These ecosystems are therefore considered as separate formations (*Pteris dentata* Shrubland, compare Figure 8). Forest edge thickets and valley thickets, in contrast, are floristically similar so that a separation into two formations is not supported. The broad-leaved subtropical shrub species (Cowling *et al.* 1997), mainly *Euclea racemosa*, *Olea capensis*, *O. exasperata* and various species of *Searsia* (Moffett 2007) frequently dominate thickets on GNR together with *Salvia africana-lutea*. Among the fynbos elements, large individuals of *Leucadendron confertum* and *Thamnochortus erectus* are most common. Certain forest elements, most commonly *Sideroxylon inerme*, may join the thicket but some thicket species may also occur as trees in the Milkwood Scrub Forest.

Wetlands

The catchment areas supplying the GNR are not large enough to support permanent streams under the prevailing precipitation regime. In winter, some springs can develop and small rivers may persist until the end of October. As a result, the distribution of true wetlands is extremely limited at the GNR and is confined to a few suitable habitats. Nevertheless the diversity of different wetland habitats is considerable and it is difficult to point out one type of wetland characteristic of the GNR. As the different types are located adjacently along several environmental gradients, they will be treated as one entity. Wetlands are related to soils with a high content of organic matter, indicated by the dark colour. The ordinations placed the wetland relevés in between for-

TABLE 2.—Eigenvalues and canonical coefficients of Canonical Correspondence Analyses (CCA) for complete core dataset and fynbos relevés of core dataset

	Complete core dataset		Core dataset—fynbos	
	axis 1	axis 2	axis 1	axis 2
Eigenvalues	0.95	0.63	0.57	0.47
Environmental variables: canonical coefficients				
elevation	-0.10	0.38	-0.39	-0.11
slope	-0.01	-0.19	0.21	-0.26
aspect	-0.01	0.02	0.10	0.12
flow acc.	0.03	0.09	*	*
irradiation	-0.01	-0.78	*	*
SE wind	-0.02	-0.37	*	*
veg. age	0.91	-0.23	*	*
soil depth	0.03	-0.05	0.12	0.39
rock cover	0.01	0.10	-0.23	0.13
texture	-0.03	-0.15	0.01	0.18
pH	-0.11	0.12	0.04	-0.09
resistance	-0.03	-0.16	-0.03	0.36
Na	-0.08	-0.39	0.30	-0.02
P	0.01	-0.40	-0.04	0.20
K	0.01	0.23	-0.05	0.16
Ca	0.08	-0.11	0.12	-0.13
Mg	0.08	0.50	-0.25	-0.16

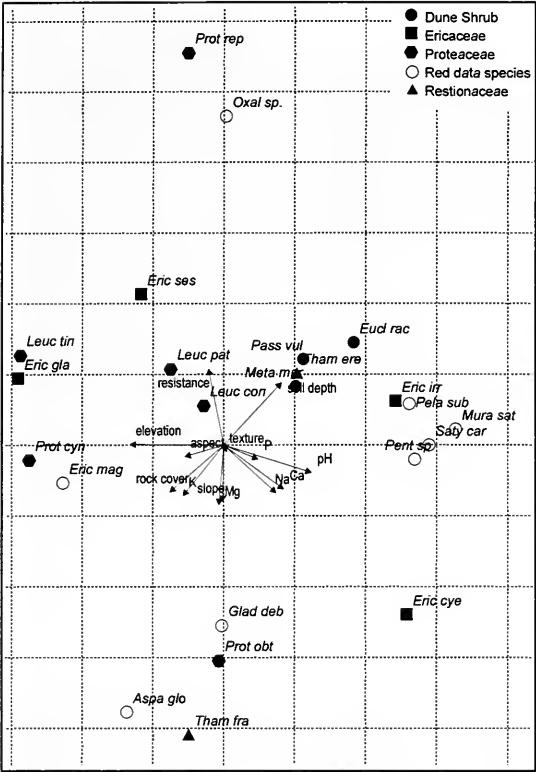


FIGURE 4.—Canonical Correspondence Analysis (CCA) biplot score for some selected species. Aspa glo, *Aspalathus globulosa*; Eric cye, *Erica coccinea* (yellow-flowered variant); Eric gla, *Erica glabella*; Eric irr, *Erica irregularis*; Eric mag, *Erica magnisylva*; Eucl rac, *Euclea racemosa*; Glad deb, *Gladiolus debilis*; Leuc con, *Leucadendron coniferum*; Leuc pat, *Leucospermum patersonii*; Leuc tin, *Leucadendron tinctorum*; Eric ses, *Erica sessiliflora*; Meta mur, *Metalasia muricata*; Mura sat, *Muraltia satureioides*; Oxal sp., *Oxalis* sp.; Pass vul, *Passerina vulgaris*; Peta sub, *Pelargonium suburbanum*; Pent sp., *Pentaschistis* sp.; Prot cyn, *Protea cynaroides*; Prot obt, *Protea obtusifolia*; Prot rep, *Protea repens*; Saty car, *Satyrium carneum*; Tham ere, *Thamnochortus erectus*; Tham fra, *Thamnochortus fraternus*.

est and fynbos without clear relationships to any of the measured variables. The pH ranges from 6.1–7.9 but the relevé with the highest value is situated below a slope that may have an alkaline character. The largest patch is located at the bottom of the forest valley. South-facing slopes are covered in a dense, 1.5 m high canopy of *Pteris dentata*, (recognized as formation *Pteris dentata* Fernland), whereas slightly north-facing slopes support mats of *Cliffortia ferruginea* and dispersed stands of *Artemisia afra*, *Leonotis leonurus* and some thicket species. *Gunnera perpensa* and *Senecio halimifolius* are dominant directly in the temporary stream. Species such as *Mariscus thunbergii*, *Hippia frutescens* and *Zantedeschia aethiopica* are present in all types. Transitions to Thicket are common. One characteristic feature of the wetlands is their low alpha-diversity with an average of only 9.3 species per relevé.

Alkaline Sand Fynbos Complex

The Alkaline Sand Fynbos Complex covers most of the lower parts of the GNR. Two hundred species were

recorded in 42 relevés, averaging at 24.9 species per relevé. The substrate is mainly wind-blown, colluvial sand of varying depth, pH and nutrient levels. Dune Asteraceous Fynbos, Neutral Sand Proteoid Fynbos and *Protea repens* Proteoid Fynbos are associated with these habitats. Some limestone outcrops show a different vegetation but they are too small to house many of the rare limestone endemics found a few kilometres to the east on larger patches. Three different limestone formations, which are frequently intermixed, have been recorded: *Protea obtusifolia* Proteoid Fynbos, *Erica coccinea* Ericaceous Fynbos and *Thamnochortus fraternus* Restioid Fynbos.

Dune Asteraceous Fynbos covers the entire western part of the GNR. It forms an extensive matrix of low ericoid/restioid fynbos, higher ericoid fynbos and thicket dominated by broad-leaved shrubs (Figure 6A). The formation is characterized by low elevation, alkaline, deep soils (> 100 cm) and low rock cover. It corresponds well with the Dune Asteraceous Fynbos described by Cowling *et al.* (1988) for the Agulhas Plain and with the Eastern Type of Coastal Fynbos (Kruger 1979). Large ericoids (*Metalasia muricata* and *Passerina vulgaris*) and non-proteoid broad-leaved shrubs (*Chrysanthemoides monnifera*) are the structural dominants, in some places joined or replaced by fabaceous shrubs, *Otholobium bracteolatum*, *Aspalathus forbesii*. *Erica irregularis* and certain non-ericaceous ericoids (*Anthospermum aethiopicum*, *Phyllica ericoides*) are widespread. *Thamnochortus erectus* is the most conspicuous restioid but the lower *Ischyrolepis eleocharis* has a very high cover in some sites. Lower individuals of the subtropical shrub species are very common all over the Dune Asteraceous Fynbos (*Euclea racemosa*, *Olea capensis* subsp. *capensis*, *O. exasperata* and *Searsia laevigata*). One characteristic feature of the Dune Asteraceous Fynbos is the lack of proteoids. If they occur, especially *Leucadendron coniferum* and *Protea obtusifolia*, they indicate a transition to other formations.

Neutral Sand Proteoid Fynbos is associated with intermediate, but varying environmental variables. The pH ranges from 4.8–7.8. The soils are usually shallower than those supporting Dune Asteraceous Fynbos, but the depths range from 0 to > 100 cm. Wind-blown alkaline sands lying over the acidic Table Mountain Sandstone provide intermediate habitats between the Dune Asteraceous Fynbos and the Acid Sand Fynbos Complex. The formation shows some association with the *Protea susannae*–*Leucadendron coniferum* Proteoid Fynbos described by Cowling *et al.* (1988) and Richards *et al.* (1995), and the Neutral Sand Proteoid Fynbos described by Mustart *et al.* (2003). These units prefer rather deep, colluvial neutral sands at least partly derived from Bredasdorp Limestone. *Protea susannae*, however, does not occur on the GNR. Instead, *Leucadendron coniferum* and *Leucospermum patersonii* are dominant with shifting composition. Relatively old, almost monospecific stands of *L. coniferum* resemble low forests with canopy heights of up to 5 m (Figure 6B), but with an extremely high density of thin stems, making them almost impenetrable. In young stands (up to 10 years after fire), the two proteoids are approximately equally abundant. An ericoid layer with variable density is present. As in the

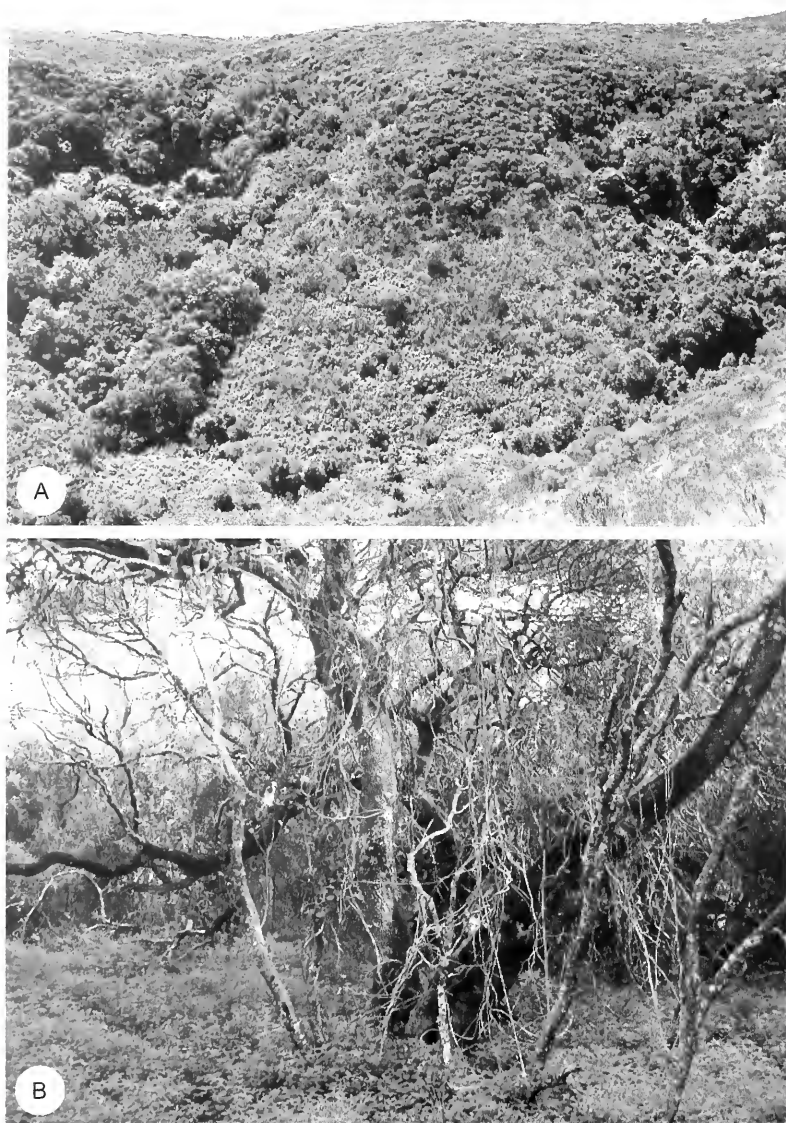


FIGURE 5.—A, patches of Afro-montane Forest concentrated in south-facing ravines (left and right); *Pteris dentata* Shrubland in centre; B, interior of Milkwood Scrub Forest. Dense undergrowth of *Droguetia iners* can only develop in light places, e.g. after anthropogenic disturbance. Photographs: M. Mergili.

Dune Asteraceous Fynbos, *Thamnochortus erectus* is the most conspicuous restioid element, whereas low restioids occur in the ground layer, together with various species of the sedge *Ficinia*. North- and east-exposed slopes of the forest valley are covered in a different vegetation unit. Owing to the high frequency of *Leucadendron coniferum* and *Leucospermum patersonii* and the scarcity of species indicating a different unit, it has been assigned to the Neutral Sand Proteoid Fynbos, but as a different unit in Figure 7.

Protea repens Proteoid Fynbos occupies the lower slopes of the Swartkransberg heading northwards towards the broad Steynsbos Valley, as well as large parts of the Steynsbos Valley itself. It forms 2.5 m high, medium-dense to dense stands of Proteoid Fynbos, associated with extraordinarily high values for electrical resistance

of the deep (> 1 m), slightly acid soils. The pH ranges from 6.4–6.7 and at the transition to the Acid Sand Fynbos Complex it is 5.6. It is inappropriate to compare this formation to the *Protea repens* Proteoid Fynbos described by Cowling *et al.* (1988) for the Agulhas Plain as it differs structurally and floristically. The formation is clearly dominated by *Protea repens*, but it shares most of its species with the Dune Asteraceous Fynbos and the Neutral Sand Proteoid Fynbos. *Leucadendron coniferum* is frequently intermixed. The ericoids *Cliffortia ilicifolia* and *Passerina vulgaris* are very frequent, growing up to more than 1.5 m, as does the restioid *Thamnochortus erectus*. A sparse to medium-dense undergrowth attains heights of some tens of centimetres. Parts of the formation were in an early post-fire stage at the time of the survey, showing a high cover of *Aspalathus microphylla* and lacking visible individuals of *Protea repens*.

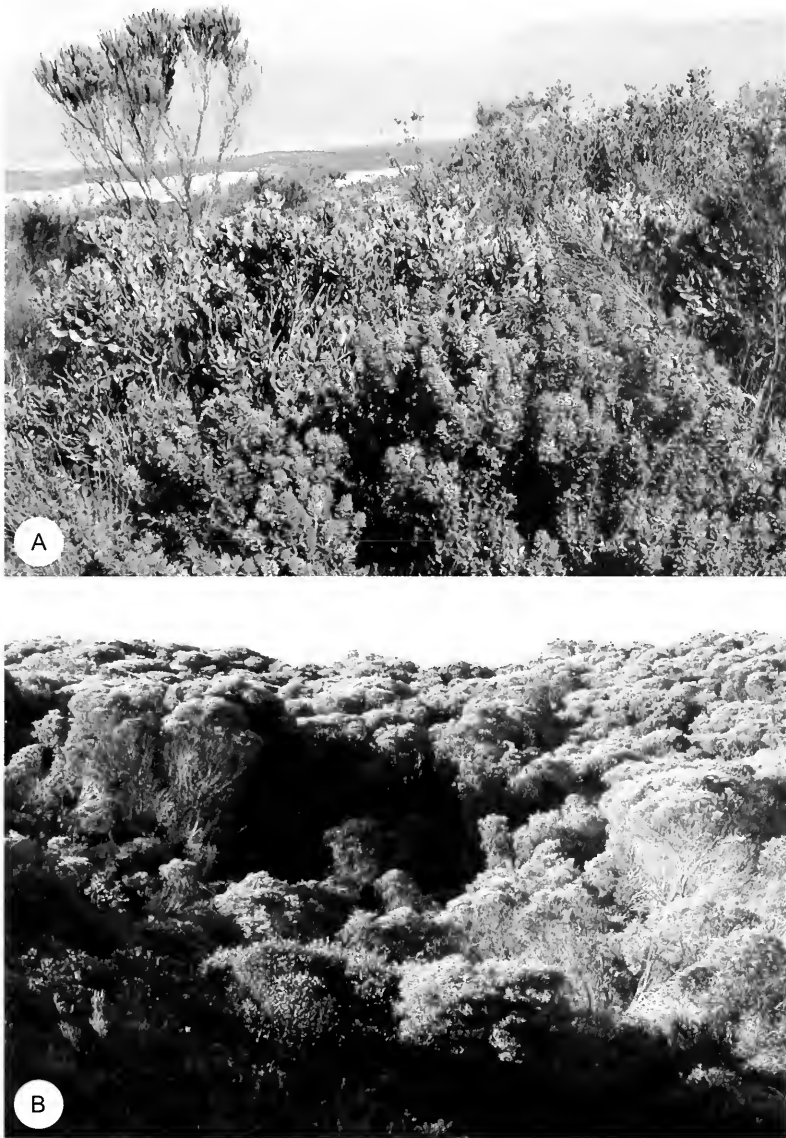


FIGURE 6.—A, Dune Asteraceous Fynbos: in foreground *Orthobium bracteolatum*, the large shrub at left, *Metalasia muricata*. Note thicket element *Olea capensis* subsp. *capensis* in centre; B, fourteen-year-old stand of *Leucadendron coniferum* (Neutral Sand Proteoid Fynbos). Photographs: M. Mergili.

Protea obtusifolia Proteoid Fynbos grows on limestone outcrops and is associated with shallow to moderately deep, alkaline soils and with low rock cover. The pH ranges from 6.9–8.1. The formation is characterized by 2 m high, sparse to medium-dense stands of *P. obtusifolia* often intermixed with *Leucadendron coniferum* and sometimes with *Leucospermum patersonii*. The bulk of the species occurs throughout the Alkaline Sand Fynbos. The formation is frequently intermixed with other formations of the Alkaline and even the Acid Sand Fynbos, sometimes on a very fine scale. Despite floristic differences, it shows affinities to the *Protea obtusifolia*–*Leucadendron meridianum* Proteoid Fynbos of the Agulhas Plain (Cowling *et al.* 1988) and to the *Leucadendron meridianum*–*Protea obtusifolia* Proteoid Fynbos of the Soetanytsberg (Richards *et al.* 1995).

Erica coccinea Ericaceous Fynbos is associated with alkaline soils rich in Na and Ca. It is not related to the

Ericaceous Fynbos of Campbell (1985) and Cowling (1988) and has its centre of distribution on rather steep limestone outcrops. It is characterized by a high cover of *E. coccinea* (yellow-flowered variant), which is frequently joined by *Indigofera brachystachya* and *Cullumia squarrosa*. Transitions to other formations of the Alkaline Sand Fynbos are common.

Thamnochortus fraternus Restioid Fynbos (Figure 8A) grows on steep limestone slopes supporting shallow, rocky, Mg-rich soils with low resistance and a pH between 7.6 and 8.0. It is structurally dominated by < 1 m high stands of the limestone endemic *T. fraternus*. The usually sparse ground cover is made up of shrubs such as *Indigofera brachystachya* or *Cullumia squarrosa*, and also *Erica coccinea* (yellow-flowered variant), the latter indicating a transition to the *E. coccinea* Ericaceous Fynbos. *Protea obtusifolia* and small individuals of *Leucadendron coniferum* may appear

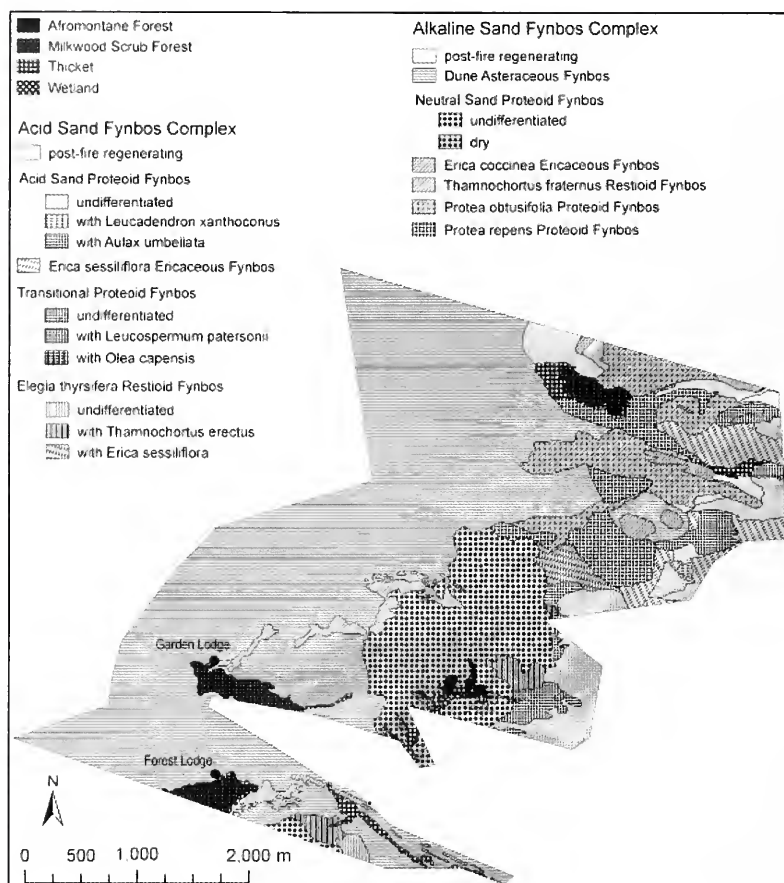


FIGURE 7.—Vegetation map of Grootbos Nature Reserve, based on orthophotos and field studies.

as well. The formation is associated to Kruger's (1979) limestone fynbos.

Acid Sand Fynbos Complex

The Acid Sand Fynbos Complex is indicated by the presence of one or more Proteaceae species associated with shallow, acidic soils derived from Table Mountain Sandstone (*Mimetes cucullatus* and *Leucadendron salignum* are the most frequent). The higher hills of the GNR are entirely covered in this complex (Figure 8B). Acid Sand Fynbos has the highest species diversity among the vegetation complexes of Grootbos, averaging at 35 species per relevé with a maximum of 48 species. One hundred and forty-nine species were recorded in the 12 relevés of the core dataset altogether. Four formations of Acid Sand Fynbos were separated in this study. Part of the complex was in an early post-fire stage at the time of the survey and was dominated by *Aspalathus ciliaris*, *Pseudopentameris macrantha*, *Thesium strictum* and *Othonna quinqueidentata*.

Acid Sand Proteoid Fynbos grows predominantly on hilltops and steeper slopes, with its largest patch on the Swartkransberg. It is associated with high elevation, shallow, rocky and acidic (pH 5.2–5.6) soils with low levels of all nutrients except K, and north-facing slopes. The formation shows environmental and structural affinities to both the *Leucadendron xanthoconus*–*Leucospermum cordifolium* Ericaceous Fynbos and the

Aulax umbellata–*Protea compacta* Proteoid Fynbos of the Soetansysberg (Richards *et al.* 1995). It is floristically and structurally characterized by the absence of species that have their centre of distribution in the Alkaline Sand Fynbos Complex and by a low to medium-dense proteoid layer usually less than 1.5 m tall, including several acidophilous Proteaceae with a changing composition and without clear dominance of one species. *Mimetes cucullatus* and *Leucadendron salignum* are the most common, joined by *Aulax umbellata*, *Leucadendron tinctorum*, *L. spissifolium*, *L. xanthoconus*, *Protea acaulos*, *P. cynaroides*, *P. longifolia* and *P. speciosa*. Several smaller species of *Erica* and further ericoid shrubs form a sparse to medium, low-height ground layer. The restioid component is variable but *Elegia juncea* in particular is abundant in some places, as is the large 'graminoid' Iridaceae *Bobartia indica*. Some of the non-sprouting Proteaceae, in particular *Aulax umbellata* and *Leucadendron xanthoconus*, may gain dominance in some places as well. According to Campbell (1986) and Cowling *et al.* (1988), part of the Acid Sand Proteoid Fynbos distinguished in this study should instead be recognized as Asteraceous Fynbos as those authors only recognize a community as Proteoid Fynbos if it contains more than 10% cover of reseeding proteoids. The resprouting *Mimetes cucullatus* and *Leucadendron salignum*, in contrast, do not fulfil this requirement.

Erica sessiliflora Ericaceous Fynbos grows on damp, south-facing slopes and in valleys. The Acid Sand



FIGURE 8.—A. *Thamnochortus fraterus* Restioid Fynbos on limestone ridge; B. Acid Sand Fynbos on southwestern slope of Swartkransberg; Acid Sand Proteoid Fynbos with *Mimetes cucullatus* and *Aulax umbellata* in foreground; Transitional Proteoid Fynbos with high cover of *Leucadendron coniferum* in background. Photographs: M. Mergili.

Fynbos elements are joined by several moisture indicators, such as *Berzelia lanuginosa*, *Cliffortia ferruginea*, *Drosera capensis* and *Psoralea arborea*. Structurally dominant is *Erica sessiliflora*, which can be up to 1.5 m high and can attain cover values of more than 75%. *Mimetes cucullatus*, *Leucadendron coniferum* and *E. glabella* are common. The largest patch occurs on the southern slope of a mountain on the Steynsbos property, but extended canopies of *E. sessiliflora* also occur on the northern slope of the Swartkransberg, indicating that the species can also cope with less moist conditions. Transitions to other fynbos formations are manifold. The formation corresponds well to the Wet Ericaceous Fynbos described by Campbell (1986) and Cowling *et al.* (1988).

Elegia thyrsifera Restioid Fynbos occupies three patches of fynbos on GNR. It is structurally domi-

nated by *Elegia thyrsifera* and *Thamnochortus erectus* which can both exceed a height of 2 m. Proteoids (*Leucadendron coniferum*, *Leucospermum patersonii* and partly *Mimetes cucullatus*) are abundant but not dominant. *Helichrysum patulum* and *Morella quercifolia* show high cover values in some places. The formation is associated with north-facing slopes and corresponds to Campbell's (1986) Restioid Fynbos although it is difficult to be assigned to one of the subseries. The sites on the GNR may represent a gradient from Mesic Restioid Fynbos with a higher share of ericaceous Ericaceae (mainly *E. sessiliflora*) to Dry Restioid Fynbos. Floristically it does not correspond to the Dry Restioid Fynbos of the Agulhas Plain (Cowling *et al.* 1988).

Transitional Proteoid Fynbos constitutes a mixture of species centred in the Alkaline Sand Fynbos, and species centred in the Acid Sand Fynbos. The transitional

character is well indicated by the CCA. The pH, however, does not exceed 6. Various subtypes of this formation are present on GNR. Some patches are structurally similar to the Neutral Sand Fynbos but acidophilous proteoids, usually *Mimetes cucullatus*, indicate the more acidic conditions. Damp ravines on the southern slope of the Swartkransberg support a thicket-like vegetation with a high cover of *Olea capensis*, but still with fynbos character. Another transition zone exists between *Protea obtusifolia* Proteoid Fynbos and Acid Sand Fynbos, leading to very complex situations with *P. obtusifolia* and *Aulax umbellata* growing almost together, but representing completely different soil nutrient regimes. The major difference to the transition described above is that it is not based on a gradual decrease of soil depth and pH-value, but on a fine-grained mosaic of young wind-blown, shallow, calcareous soils, older limestone ridges and underlying Table Mountain Sandstone. Extremely complex situations prevail at the western slope of a mountain at Steynsbos, where *Leucadendron coniferum*, *Leucospermum patersonii* and *P. obtusifolia* coexist with some of the acid sand proteoids.

Vegetation mapping

The vegetation units illustrated in the map (Figure 7) largely correspond to the units established in the analysis. Only a few changes were made (e.g. patches of fynbos in early post-fire stages). An additional level of detail was introduced in some cases. Most of GNR is covered in Fynbos (1 620 ha or 95.3%). Forest & Thicket account for 78 ha or 4.6% (Afromontane Forest 4.1 ha or 0.2%, Milkwood Scrub Forest for 43 ha or 2.5% and Thicket for 30.9 ha or 1.8%), whereas only 1.4 ha (0.1%) are covered in Wetland. Dune Asteraceous Fynbos covers more than half of GNR (914 ha or 53.8%), and the whole Alkaline Sand Fynbos Complex occupies 1 385 ha or 81.5%. Even the second largest formation of this complex, the Neutral Sand Proteoid Fynbos (191 ha or 11.3%), approaches the same amount of cover as the whole Acid Sand Fynbos Complex (235 ha or 13.8%).

Figure 7 also gives an idea of the fragmentation of the vegetation units. The interpretation of this information has to be approached with caution because the fragmentation may be caused by different factors, including the shape of GNR. Dune Asteraceous Fynbos and Neutral Sand Proteoid Fynbos cover continuous, hardly fragmented areas with average patch sizes of 305 and 96 ha, respectively. *Protea repens* Proteoid Fynbos and *Erica sessiliflora* Ericaceous Fynbos also exceed average patch sizes of 25 ha. In contrast, the distribution of Limestone Fynbos is rather patchy, with 27 patches ranging from tens of hectares of *Protea obtusifolia* Proteoid Fynbos to tiny limestone outcrops covered with *Thamnochortus fraternus* Restioid Fynbos. The average patch size (6 ha) is not representative in this case. In the Forest the patch size of the highly fragmented Afromontane Forests remains below 1 ha (0.81), whereas the patches of Milkwood Scrub Forest occupy slightly more than 10 ha on average.

DISCUSSION

Three levels of vegetation units were established on the GNR: the vegetation type level and the vegetation

complex level were based on environmental conditions and species groupings (TWINSPAN), and the formation level on dominant species.

The units of the vegetation type level largely correspond to the biome level of the Broad Habitat Units established by Cowling & Hejnis (2001), based on environmental variables. The Fynbos and Forest Biomes occur on GNR, the Thicket Complex identified in this study does not correspond to the Thicket Biome of Cowling & Hejnis. The complexes of this study correspond partly to the primary units. Campbell (1985) considered Forest and Thicket as one group, as in this study. Wetlands are neither considered by Campbell (1985) nor by Cowling & Hejnis (2001). Cowling *et al.* (1988) classified them as azonal vegetation.

The separation of the fynbos on GNR into an Alkaline and an Acid Sand Fynbos Complex seems sufficiently supported by the classification and the ordinations. The two complexes correspond to the Coastal Fynbos (or Lowland Fynbos) and Mountain Fynbos, respectively (Acocks 1953; Taylor 1978; Kruger 1979; Moll *et al.* 1984). According to Cowling *et al.* (1988), a separation of fynbos in this way has to be rejected because none of the structural units (Campbell 1985) are restricted to one of those groups, and because the floristic changes within the Mountain Fynbos are as significant as between Mountain Fynbos and Lowland Fynbos. However, this study shows that it appears to be highly relevant on a local scale, where the gamma-diversity does not play the role it does on a broader scale while the beta-diversity is still high.

The division of the complexes into proper communities presents problems. Most subcomplex vegetation units are based on one or a maximum of two dominant species which give the landscape a very characteristic appearance. Nevertheless, the classic concept of plant communities as an association of several characteristic species which differentiates it from other communities should not be applied to these entities. The structural component in such a classification is evident, and the groups (here called formations) show a fairly strong correlation to the classification systems of Campbell (1985) and Cowling *et al.* (1988) where structural features of the vegetation were included more systematically. The difficulty of purely floristic classification systems in the Fynbos Biome, due to high gamma-diversity, is illustrated by comparing the findings of this study to the vegetation study of Richards *et al.* (1995) for the Soetansberg. Despite environmentally comparable conditions and a distance of < 50 km, substantial floristic differences, also among the dominant species, are evident.

The expected dependence of fynbos vegetation on certain environmental factors was confirmed by the study. The major explanatory variables in the CCA of Richards *et al.* (1995) in their vegetation study of the Soetansberg were pH, rock cover, soil depth and soil texture. Apart from soil texture, which was investigated in more detail than in this study, the explanatory variables are the same as for GNR. Elevation, which plays a major role here but not in the Soetansberg, is probably mainly a surrogate for the aeolian sediment accumula-

tion budget, wind speed and the distribution of different substrate types, as the correlation values (e.g. 0.78 with pH) indicate.

The clustering of the relevés in the DCA and the CCA was rather poor (compare Figures 2B; 3B) and the transitions between the fynbos units many. Only the Acid Sand Proteoid Fynbos formed a clear cluster, together with some relevés of Transitional Proteoid Fynbos. This finding is partly in line with the study of Richards *et al.* (1995): the relevés connected to low pH (sandstone) were poorly clustered in the CCA biplot, but they were clearly separated from the relevés on limestone. On GNR, the transition between the limestone formations and the remaining formations was continuous with the Neutral Sand Proteoid Fynbos as intermediate formation, but rather with affinities to the limestone formations. In contrast, the *Protea susannae*–*Leucadendron coniferum* Proteoid Fynbos of Richards *et al.* (1995), a formation that is associated with neutral sands according to Cowling *et al.* (1988), did not differ substantially in pH from the sandstone formations, but was clearly discriminated from the limestone formation (*Protea obtusifolia*–*Leucadendron meridianum* Proteoid Fynbos).

The poor clustering in the fynbos of the GNR may be explained by a variety of factors. The location of the relevés (some of them were placed in transitional zones) and the high level of detail in the study (leading to a considerable amount of noise) may serve as one explanation, the topographic and geological patterns on GNR as another; alkaline sands cover the entire western part of the GNR, and limestone ridges of varying shape and size are widely dispersed. This leads to wind-blown alkaline sands of variable depth over large parts of acid substrate and to an extremely fine-scaled pattern of different physical and chemical substrate properties. This is especially true for the foothills and the lower slopes of the higher hills of GNR, leading to very complex vegetation patterns; in some places *Aulax umbellata*, a strong indicator of acidic conditions, and *Protea obtusifolia*, a strong indicator of alkaline conditions, grow immediately adjacent to each other. Only the highest parts of the GNR, the Acid Sand Fynbos Complex, remain untouched and do not contain calcareophilous species. In such a fine mosaic of different environmental conditions, the vegetation is sensitive to influences other than topographic and substrate variables. The problems with grouping fynbos ecosystems based on reseeding proteoids (Richardson & Van Wilgen 1992; Privett *et al.* 2001) are well established, as these organisms are susceptible to local extinction ('drifting clouds of species abundance'). Therefore the structural dominants of the vegetation of a certain place may shift from fire interval to fire interval, as Privett *et al.* (2001) have shown for the Cape Peninsula. However, this phenomenon only occurs at a subcomplex level. The boundaries of the fynbos complexes are not affected as steep environmental gradients prevent mixing of the species pools (high beta-diversity).

Figure 9 represents the floristic diversity of the vegetation of GNR at the complex level. Fynbos and Forest constitute completely different species pools. Less than ten taxa occur in both vegetation types, whereas Acid Sand Fynbos and Afromontane Forest share no taxa at all. In contrast the complexes within each vegetation

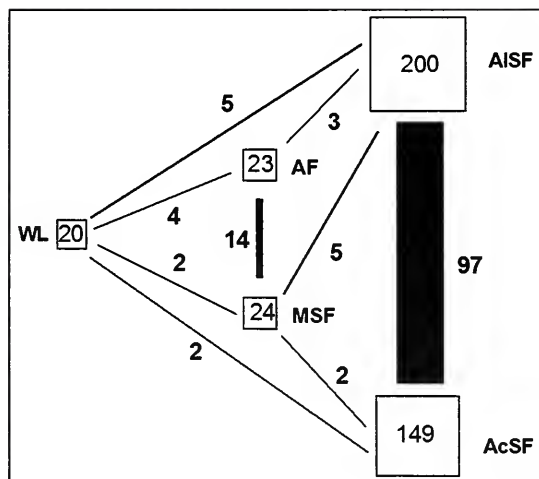


FIGURE 9.—Species diversity of vegetation complexes of Grootbos Nature Reserve. Size of each box and number inside indicate total species number of complex, whereas width of lines and adjacent numbers indicate number of species shared by two complexes. AcSF, Acid Sand Fynbos Complex; AIFS, Alkaline Sand Fynbos Complex; MSF, Milkwood Scrub Forest; AF, Afromontane Forest; WL, Wetland.

type share a considerable number of their taxa. Wetland shares only a few taxa with the other groupings, but the low diversity of the wetland may contribute to this phenomenon. Although the Alkaline Sand Fynbos hosts more taxa (200) than the Acid Sand Fynbos (149), the diversity of the latter is more than four times higher if normalized to the area (0.63 and 0.14 taxa per hectare respectively). Even though this ratio may be of limited value, it confirms the general patterns obtained from the relevé data.

As a conclusion, it can be stated that the vegetation patterns of GNR were investigated in great detail, leading to a differentiated picture of the spatial distribution of the vegetation units and the vegetation-environment relationships. The major implications for further management is the potential impact of fire on vegetation structure, in particular the vegetation units dominated by reseeding proteoids. Careful planning to mimic natural fire frequencies and conditions will be necessary in order to prevent local extinction. In order to protect Red Data species, particular care has to be taken when undertaking controlled burns of extreme habitats, such as steep limestone ridges and sandstone slopes.

SHORT NOTE

In February 2006, after the submission of this paper, the fynbos ecosystems of the entire GNR were burnt by a fire. Since then, the number of species recorded has increased from 660 to 732 (Privett & Lutzeyer in press) and two further new species (*Capnophyllum* sp. nov. and *Pterygodium* sp. nov.) were recorded.

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Resource demand estimates for sustainable forest management: Mngazana Mangrove Forest, South Africa

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Keywords: *Bruguiera gymnorhiza* (L.) Lam., construction timber, Eastern Cape, forest product utilization, mangroves, *Rhizophora mucronata* Lam., rural building styles, sustainable forest management

ABSTRACT

Since democratization in 1994, South African forest policies have promoted sustainable forest management. However, implementation has been problematic due to limited information concerning forest product utilization. This paper investigates and quantifies timber use from the Mngazana Mangrove Forest, Eastern Cape Province, South Africa. Three local communities utilize stems of the mangrove species *Rhizophora mucronata* Lam. and *Bruguiera gymnorhiza* (L.) Lam. for building construction. There were two distinct building shapes, circular and rectangular. On average, 155 stems were used for circular buildings and 378 stems for rectangular buildings. Most buildings were constructed using mangroves as well as indigenous timber from coastal scarp forests. The proportion of mangrove stems in buildings varied from 0 to 95%. The annual demand for mangroves was estimated to be 18 400 stems. Due to the high annual demand, projected human population growth rates have a minor influence upon future demand values. For effective sustainable forest management, the standing stock at Mngazana should be restricted to the two mangrove species utilized for building construction, and a forest inventory performed so that demand for building can be compared to supply.

INTRODUCTION

Over the last decade, global advancements in forest management have progressed towards Sustainable Forest Management (SFM), a term first incorporated into Agenda 21 and the Forest Principles which were both outputs of the United Nations Conference on Environment and Development (UNCED) 1992. Agenda 21 called for enhanced sustainable management of all forests, whereas the Forest Principles stated that ‘forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations’. It also specified that these needs include forest products such as wood and wood products (United Nations General Assembly 1992: 291, 292). Since its inception, the SFM concept has evolved through international forest policy dialogue, as well as country and eco-regional initiatives. These activities have resulted in global alterations to forest policies and forest management strategies (FAO 1994).

Although South Africa did not participate in UNCED, global developments have influenced its policies and since democratization in 1994, forest policy has striven to broaden access and sustainable use of indigenous forests (Lawes *et al.* 2004a). The new South African Constitution promotes conservation, ecologically sustainable development and the use of natural resources within justifiable social and economic development (RSA 1996a). Furthermore, the White Paper on Sustainable Forest Development in South Africa (RSA 1996b), and the National Forest Act (RSA 1998), both

acknowledge the vital role of forests in the livelihoods of rural communities. These policies recognize the obligation which the country has, to use its natural resources to further the development of the poor (Willis 2004). Thus, South African policy promotes the sustainable use of forests. Forest biomes and their management have been well researched (Muir 1990; Oribi *et al.* 2002; Lawes *et al.* 2004a), but implementation of management plans sometimes poses a problem. There is also a paucity of information on the usefulness of the forests, especially to local people and on actual removal of wood and other products (Lawes *et al.* 2004).

SFM approaches have been applied to mangrove forests (International Tropical Timber Organization 2002), but no examples exist for South Africa’s mangroves, even though their forest products are utilized by local communities (Bruton 1980; Ward *et al.* 1986; Steinke 1999; Rajkaran *et al.* 2004). Mangroves in South Africa are located along the Indian Ocean coastline in the provinces of KwaZulu-Natal and Eastern Cape. Over 17 years, a reduction of 7% in mangrove area has been reported for the Eastern Cape, and easily accessible forests that lie outside of protected areas are under great pressure from resource users (Adams *et al.* 2005). Mangrove ecosystems have a positive influence on coastal protection, nutrient cycling and export, sediment trapping, and serve as breeding and nursery grounds for fish (Lugo & Snaedakar 1974; Hogarth 1999; Mumby *et al.* 2004). South African mangrove habitats are threatened and as a result, many authors have called for greater conservation and management efforts (Branch & Grindley 1979; Day 1981; Ward *et al.* 1986; Berjak *et al.* 1997; Steinke *et al.* 1995).

The Mngazana Mangrove Forest (MMF) in the Eastern Cape was selected for study, as mangrove trees have been harvested throughout the forest (Rajkaran *et al.* 2004) and local communities use them with other

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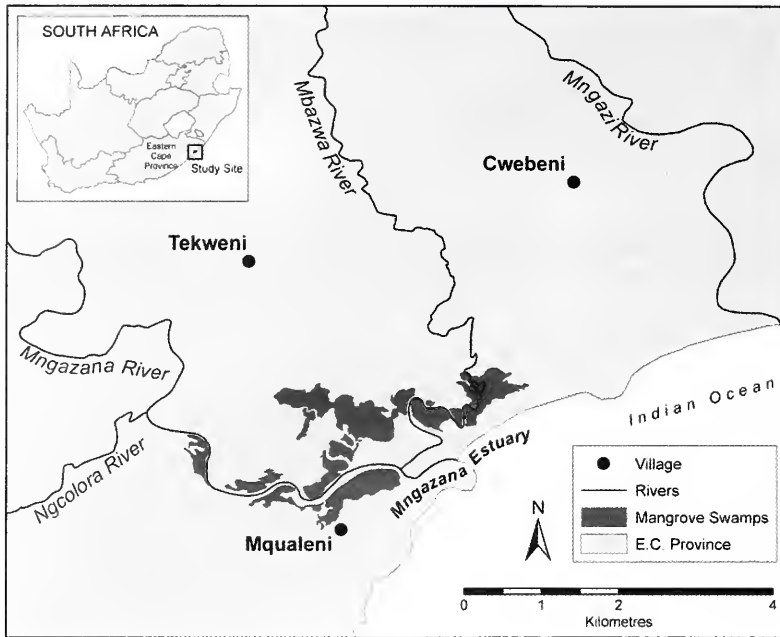


FIGURE 1.—Location of the Mngazana Mangrove Forest and study villages, Eastern Cape, South Africa.

indigenous wood species as building construction materials. In the villages surrounding the mangroves there are limited employment and income opportunities. People have restricted means to purchase building construction materials and thus over 90% of dwellings are traditional huts or structures made from natural materials (Statistics South Africa 2001). Every South African citizen has the right to access adequate housing (RSA 1996a) and the communities at Mngazana are dependent upon the local natural resources, including the mangrove forest, to meet their housing needs. At Mngazana the buildings are typical of rural styles constructed from indigenous wood; a wooden framework is made to which stone and mud walls and roofing materials are added (Liengme 1983; Cunningham 1985; Shackleton *et al.* 2002).

This paper investigates the SFM concept focusing on the estimation of empirical values for forest product utilization. Through the case of the MMF, the intricacies of precisely calculating demand for housing construction timber is presented and the usefulness of these estimates to SFM considered. Firstly, the total numbers of mangrove stems within standing structures is quantified. Secondly, the current annual demand for mangrove stems for building construction is evaluated. Thirdly, future demand for mangrove stems is predicted under different scenarios. Finally, the contribution the demand estimates can make to a mangrove SFM strategy and the wider relevance of the case is discussed.

The context of the Mngazana Mangrove Forest

The topography of the Mngazana area is a tidal flat, up to 1 500 m wide in places, attributed to the geological formation, the Ecca and Beaufort Groups of the Karoo Sequence (Harrison *et al.* 1999). These groups are composed of conglomerates, sandstones and mudstones which produce weakly structured, shallow soils when

weathered (Nicolson 1993). The average annual rainfall is 1 200 mm, and 70% occurs in summer. The vegetation includes a coastal strip of dune forest, mangroves, salt-marsh and inland grassland and forest patches.

The MMF is a riverine mangrove forest that is situated within the Mngazana Estuary (31°42'S 29°25'E), Eastern Cape. It is the third largest mangrove forest in South Africa (Ward & Steinke 1982) covering an area of ± 145 ha (Adams *et al.* 2005) and is composed of the mangrove species *Avicennia marina* (Forssk.) Vierh., *Bruguiera gymnorhiza* (L.) Lam. and *Rhizophora mucronata* Lam. The estuary is biologically important with the highest recorded invertebrate diversity for east coast estuaries (Branch & Grindley 1979) and rated first in the region using a botanical importance rating system (Colloty 2000) and 22nd in South Africa for its biodiversity importance (Turpie *et al.* 2002). The MMF has been heavily disturbed, and Rajkaran *et al.* (2004), using GIS analysis, estimated that over 40% of the forest showed a ratio of one adult tree to two harvested stumps, indicating that the harvesting intensity was extremely high.

The area is inhabited by Xhosa-speaking Mpondos. Prior to democracy in 1994, the area was classified as a homeland by the apartheid government and consequently is poorly developed (Ashley & Ntshona 2003). There are three villages surrounding the Mngazana Estuary; Mqualeni, Cwebeni and Tekweni (Figure 1). In these villages, $\pm 30\%$ of the population have received no schooling, less than 10% of the labour force are employed and over half of the homesteads are female-headed (Statistics South Africa 2001). The land is in trust to the Tribal Authorities but owned by the state, and community members may utilize the land subject to legislation and local rules. The communities at Mngazana and a non-profit organization hope to devise a SFM plan for the mangrove forest that will permit mangrove harvesting.

METHODS

Investigations focused upon *Rhizophora mucronata* and *Bruguiera gymnorhiza* as these species are utilized exclusively for building construction. They are harvested by cutting the main stem at its base; this entire stem minus branches is used in building construction. It has been suggested that *R. mucronata* can regenerate after cutting 'if cut high enough on the stem that live branches (with leaves) are spared' (Walters 2005a: 344), but coppicing of cut stems has never been observed at Mngazana for *R. mucronata* and *B. gymnorhiza* (Adams *et al.* 2005) and thus, under the current cutting regime, one stem equates with one tree destructively harvested. Therefore, demand (and supply) calculations can use numbers of individual trees rather than weight and volume measurements of wood.

Mangrove utilization for building construction purposes has been determined through empirical observations supplemented by information from semi-structured interviews with homestead occupants and group discussions. As house construction activities only occur every few years, a respondent's recollections concerning quantities of materials used may not be very precise, so empirical observations are generally more reliable (Shackleton & Shackleton 2004). The villages of Mqualeni, Cwebeni and Tekweni were selected for study. There are 574 homesteads in these villages (Statistics South Africa 2001) and of these, 108 (19%) were randomly selected and surveyed, 32 in Cwebeni, 48 in Tekweni and 28 in Mqualeni. The semi-structured interviews with homestead occupants were in Xhosa (the vernacular language spoken in the area) with English translation. The interviews were designed to elicit information regarding mangrove characteristics, utilization and building longevity. Within each homestead the number and shape of individual buildings were recorded. Buildings constructed with mangroves were identified and the number of mangrove poles utilized in each structural unit (wall poles, roof poles and roof laths) was counted. The diameter of mangrove stems used in each structural unit was determined by sampling a random ten exposed stems and measuring the diameter using metal callipers to the nearest millimetre. The length of stems used for different units was obtained through group discussions. The presence of alternative building materials was also recorded. Three group discussions with community members were held from October 2003 to October 2004 and relevant information from these has been included for comparative purposes. Groups were composed of members of the Mngazana Mangrove Management Forum and interested villagers from all three villages, between 11 to 20 people attended each meeting.

Human population growth rates were estimated from the 2001 South African census (Statistics South Africa 2001) and the population estimates of the United Nations (United Nations 2005). The following terminology will be used throughout this paper: homestead: an area allocated for a family's dwellings, usually consisting of several different individual buildings; mangrove used as a prefix to structural unit, building or homestead denotes use of mangroves in construction. Utilization was cal-

culated at different scales of structural unit, building, homestead and village using the procedure summarized in Figure 2.

RESULTS

Mangrove utilization

Group discussions and direct observations indicated that the main use of mangroves is for building construction: *Rhizophora mucronata* and *Bruguiera gymnorhiza* are the only species utilized for this purpose. An extremely small minority of homesteads used these species for non-building construction purposes such as fencing. *Avicennia marina* was collected by some homesteads for fuel wood; dead wood was preferred to green wood. There was a low frequency of collection because non-mangrove tree species were also utilized for fuel wood. This study focuses upon construction use because it is the predominant use of green mangrove wood.

Mangrove stems in standing structures

Buildings constructed from mangroves are circular or rectangular. Both of these shapes are constructed from structural units of wall poles, wall laths and roof poles. Wall poles are positioned vertically and then laths laid at ninety degrees to these to produce a framework.

The average number of mangrove stems used in building units constructed *entirely* from mangroves was calculated for all three villages (Table 1). A circular building if constructed entirely from mangroves would utilize 155 stems, ± 110 of these would be wall laths and the remainder wall or roof poles. Rectangular buildings composed of only mangrove stems utilize more than double the number of stems (± 378 stems), because the wall laths require 335 ± 151 stems. Requirements for wall and roof poles are approximately similar. The average diameter of poles was 6.1 ± 2.0 cm ($n = 787$) and the average diameter of laths was 3.3 ± 1.0 cm ($n = 550$). Group discussions revealed that poles and laths over 2 m long were utilized.

However, mangroves are utilized in conjunction with other timbers, the percentage of mangroves within these structural units shows variation (Figures 3, 4). Mangroves compose a high percentage of building mate-

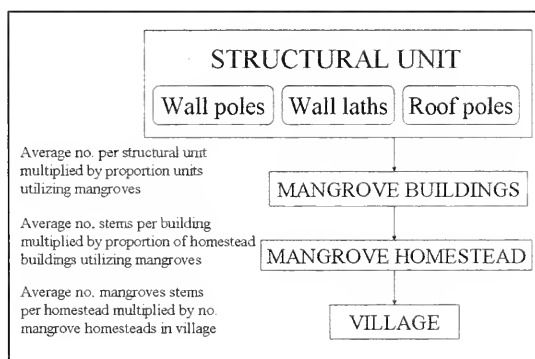


FIGURE 2.—Summary of method used to calculate demand for mangrove stems within each village.

TABLE 1.—Average no. mangrove stems (\pm std dev.) per building unit constructed *entirely* from mangroves in three villages studied

	Tekweni	Cwebeni	Mqualeni	Average
Circular building				
Wall poles	22 (n = 1)		24 \pm 10 (n = 3)	23 \pm 8 (n = 4)
Wall laths		96 (n = 2)	125 \pm 7 (n = 2)	111 \pm 17 (n = 4)
Roof poles	19 \pm 6 (n = 37)	24 \pm 5 (n = 21)	22 \pm 2 (n = 2)	21 \pm 6 (n = 60)
Extrapolated				155
Rectangular building				
Wall poles		30 \pm 6 (n = 2)		25 \pm 9 (n = 10)
Wall laths	336 \pm 69 (n = 3)	372 \pm 172 (n = 19)	281 \pm 118 (n = 13)	335 \pm 151 (n = 35)
Roof poles	10 \pm 1 (n = 2)	15 \pm 6 (n = 2)	44 (n = 1)	18 \pm 15 (n = 5)
Extrapolated				378

rials in the roof poles of circular buildings (up to 100%) and the wall laths of rectangular buildings (75% or more). In other structures, mangroves account for 50% or less of materials. The percentage of mangroves utilized showed variation between the villages studied. Mqualeni Village showed the most consistent use of mangroves and they were utilized in all structural units composing \pm 30% to 80% of all stems. In Cwebeni and Tekweni, the percentage of mangroves used shows wider variations. All the roof poles in circular buildings in these villages are mangroves, but mangroves make up 10% or less of wall poles and laths. Rectangular buildings in these two villages display different patterns; mangroves make up 75% or more of wall laths but only up to 25% of wall and roof poles.

A one-way between-groups analysis of variance was conducted to explore the impact of village location upon the number of mangrove stems used in different-shaped buildings. There was a statistically significant difference at the $p < 0.05$ level for the number of mangroves stems per circular building between villages ($F(2, 59) = 10.7$, $p = 0.00$). Post-hoc comparisons using the Turkey HSD test indicated the mean score for Maqualeni ($M = 72.80$, $SD = 64.76$) was significantly different from Cwebeni ($M = 33.00$, $SD = 28.70$) and Tekweni ($M =$

20.17, $SD = 7.50$). There was no statistically significant difference at the $p < 0.05$ level in the number of mangrove stems used in rectangular buildings between villages ($F(2,36) = 2.32$, $p = 0.11$).

Typical homesteads in the villages studied consist of circular and rectangular buildings, constructed from a variety of materials including indigenous timber and blocks.

Thus a conversion factor was utilized to estimate the number of mangrove stems utilized per homestead (Table 2). This conversion factor was the average number of mangrove stems in mangrove buildings multiplied by the average number of buildings containing mangroves in homesteads (that utilized mangroves). Accounting for these variations, mangrove homesteads used an average of 89 stems in Tekweni, 346 stems in Mqualeni and 397 stems in Cwebeni. The percentage of homesteads utilizing mangroves was 54% in Tekweni, 79% in Mqualeni and 88% in Cwebeni.

At the village scale, the total number of homesteads using mangroves was 67 in Mqualeni, 96 in Tekweni and 272 in Cwebeni and the estimated total number of mangrove stems utilized was 8 581 stems in Tekweni, 23 108 stems in Mqualeni, 108 034 stems in Cwebeni. Thus in total, 139 723 mangrove stems were utilized in standing structures within buildings at the time of the study.

Current annual demand for mangrove stems (2004)

The percentage of new buildings compared to the total number of buildings was 3% in Tekweni, 16% in Cwebeni and 18% in Maqualeni. As the different-shaped buildings utilize different amounts of mangrove stems,

TABLE 2.—Conversion of mangrove utilization figures from buildings to homestead level

	Tekweni		Cwebeni		Mqualeni	
	C	R	C	R	C	R
Average no. stems per building (a)	21	255	33	358	61	254
Average no. buildings containing mangroves per homestead (b)	0.37	0.32	0.43	1.07	0.55	1.23
Average no. mangrove stems per homestead by building shape (a \times b)	8	81	14	383	34	312
Total average no. mangrove stems per homestead	89		397		346	

C, circular building; R, rectangular building.

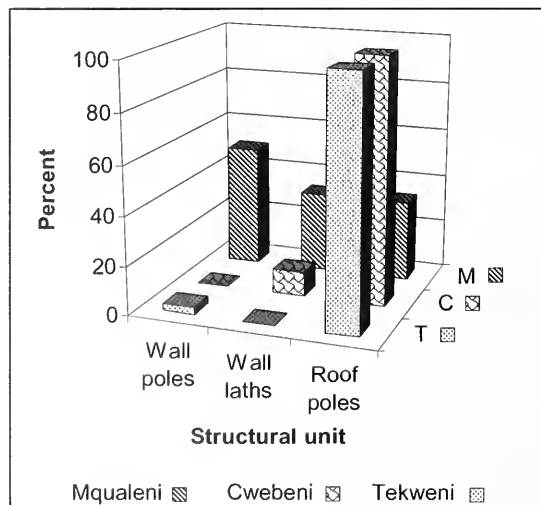


FIGURE 3.—Percentage of mangrove stems used within structural units in circular mangrove buildings.

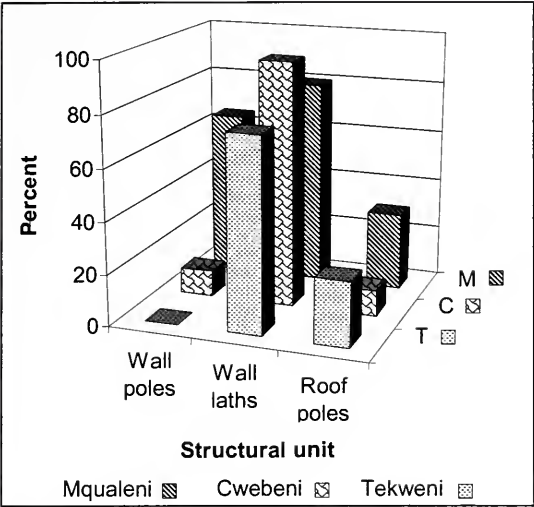


FIGURE 4.—Percentage of mangrove stems used within structural units in rectangular mangrove buildings.

the shape of buildings constructed has an important influence upon demand for mangrove stems. The ratio of circular to rectangular mangrove buildings in the villages studied was 1:1, thus the current demand for stems can be calculated using this building shape ratio. Circular buildings utilize fewer mangrove stems than rectangular buildings, thus demand from circular buildings represents the minimum number of stems necessary to fulfil housing requirements and demand from rectangular buildings represents maximum demand. Using these demand scenarios, the minimum demand would be for 3 700 stems, the 1:1 demand would be for 18 400 stems and the maximum demand for 33 500 stems (Figure 5).

Group discussions suggested that the longevity of mangrove buildings was 10 years and homestead surveys suggested an average of 20 years, thus, the average is 15 years.

Predicting future demand scenarios

Future demand for mangrove stems can be estimated using human population growth predictions derived from past growth rates or demographic models. Past rates (1996–2001) of annual human population growth in all three villages was 3% (Statistics South Africa 2001). However, this census data may underestimate the impact of HIV/AIDS upon the population and as the most direct demographic consequence of HIV/AIDS is an increase in mortality (Whiteside 2001) demographics will change. The United Nations demographic models take account of the effect of HIV/AIDS and in South Africa annual human population growth rates were estimated to be 0.78% for the period 2000 to 2005 (United Nations 2005).

The influence of a decade of human population growth on mangrove stem demand can be estimated using the different human population growth forecasts and various building-shape scenarios (Figure 6). These estimates suggest that under the 0.78% human population growth rate, demand in all building scenarios over

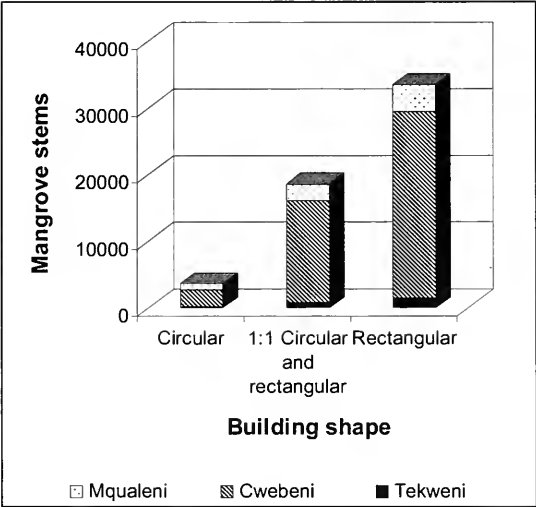


FIGURE 5.—Demand for mangroves in 2004 under different building-shape scenarios.

the next ten years will increase gradually but it will not exceed more than 0.5% of the current demand figure. Under the 3% human population growth forecast, demand for mangrove stems increases by 6% of current estimated values, and in the maximum demand scenario of rectangular buildings, an additional 2 628 stems per year would be required in 2015 compared to current values.

DISCUSSION

The investigations have demonstrated that different-shaped buildings require a different total number of resource stems. In buildings constructed entirely from

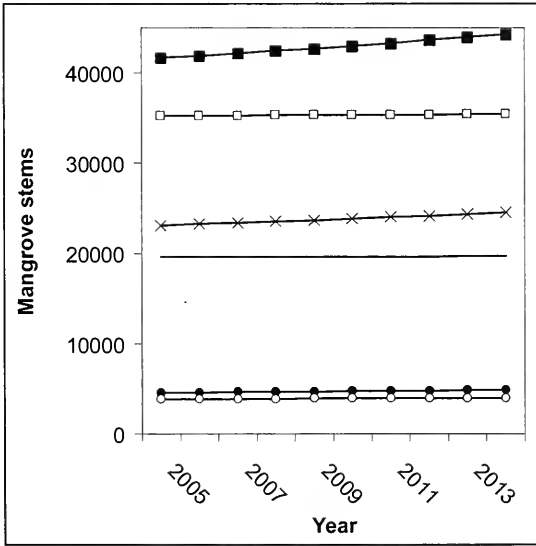


FIGURE 6.—The predicted demand for mangrove stems under different population growth forecasts and building-shape scenarios. —■— 3% growth (rectangular); —○— 0.78% growth (rectangular); —×— 3% growth (circular and rectangular); —— 0.78% growth (circular and rectangular); —●— 3% growth (circular); —○— 0.78% growth (circular).

mangroves, rectangular buildings require $\pm 100\%$ or over 200 more stems than circular buildings. Liengme (1983) found that rectangular buildings used $\pm 50\%$ more poles than circular buildings, the main difference attributable to rectangular buildings having two rather than one row of roof poles. In the current study, the major variation between building shapes was in the number of wall laths required.

Buildings in the current study are rarely constructed entirely from mangroves and species combinations have also been documented in other parts of South Africa (Liengme 1983). The proportion of mangroves used varies with structural unit and building shape. Mangroves are the preferred materials for circular building roof poles and rectangular building wall laths. Shackleton *et al.* (2004) reported that proportions of species could alter within walls and roofs. In the current study, mangroves composed a higher percentage of rectangular than circular building stems.

The average distance from surveyed homesteads to the mangrove boundary was 393 m in Mqualeni, 1 733 m in Tekweni and 2 040 m in Cwebeni. Mangrove use varied spatially between the villages; mangroves are used for all structural units in both circular and rectangular buildings in Mqualeni Village, however in Tekweni they are rarely used as roof poles and never used as circular building wall laths. Circular buildings have curved walls and group discussions revealed that indigenous species from the coastal scarp forests were preferred for this purpose because they were more flexible than mangroves. In Mqualeni Village, mangroves were often used for circular wall laths as the mangrove resource was nearby, ± 400 m from homesteads. Similar examples of resource selection for less preferred species due to higher availability and ease of collection have been documented by Nomtshongwana (1999) and Walters (2005b). In the current study, the relationship between mangrove use and distance to the mangroves was confounded by the fact that mangrove use was also affected by utilization of alternative building materials such as indigenous timbers and sand blocks.

Utilization evaluation at the homestead scale shows a variety of mangrove and non-mangrove materials used for both circular and rectangular buildings. Homesteads in Tekweni use approximately a quarter the amount of mangroves compared to homesteads in the other villages studied. Tekweni is the furthest distance from the mangrove forest and also has proximity to the coastal scarp forest that can provide building construction materials (Obiri 1997). Analysis of use at the village scale indicates that observed differences at the homestead scale are generally enlarged at the village scale. Tekweni Village which has homesteads with the lowest utilization values, the lowest percentage and actual number of mangrove homesteads, is estimated to have used less than 9 000 mangrove stems. Cwebeni Village at the other extreme, has high homestead utilization values and a high percentage and actual number of mangrove homesteads. These factors combine to produce utilization figures of approximately 100 000 stems.

Demand for a resource may constantly change and the dynamic needs to be understood (Ellery *et al.* 2004).

Both the annual and predicted demand for mangrove stems is influenced greatly by building shape. The annual demand for mangrove stems is based upon the percentage of sampled homesteads that were observed constructing new mangrove buildings, the value in Mqualeni was over 50%. This high value may indicate that this category of homestead was over-sampled. However, as Mqualeni is a small village, its influence on the overall demand for mangroves from Mngazana Forest is relatively limited. The high annual demand indicates that many homesteads are constructing new buildings on their land. These tend to be required due to a change in individual circumstance often with young adults requiring the privacy of a separate building.

The influence of human population growth rates of 0.78% or 3% upon demand is limited as the current demand rates are high when compared to the demand changes due to population growth which are relatively small. The differences in values between current demand in 2004 and predicted demand in 2015 due to human population growth suggest that there are factors other than human population growth which are influencing the construction of new buildings. These factors may include maturing children who desire their own private room or marriage of family members who remain on the homestead and family members returning to live at the homestead such as migrant workers. Although demand is predicted to show minor changes due to human population growth rates, it could change drastically due to the shape of the new buildings being constructed.

In the past, fuel wood models were devised that predicted future demand scenarios and an impending 'fuel wood crisis', however this never materialized; the models failed partly because they did not appreciate the complexity of rural energy and focused upon supply without accounting for demand changes (Shackleton *et al.* 2004). Humans demonstrate adaptability to resource decline and increasing scarcity and Shackleton (1993) reported that where demand for the preferred fuel wood—dead wood—outstripped supply, harvesters responded by selecting the non-preferred live wood resources and even developed strategies to circumvent legislation. Factors such as these may well influence the demand scenarios presented for Mngazana, particularly as although mangroves are generally preferred for building construction, the inhabitants are not strictly reliant upon them and can obtain alternative timber resources from the indigenous terrestrial forests or use mud or sand blocks for construction.

A previous study concerning wood utilization for building construction focused upon quantities used per building (Liengme 1983). This study demonstrates that the number of stems required per building, the proportion of a species used in different structural units, the building shape and the proportion of buildings constructed from different materials must all be evaluated so that a realistic estimate of wood use can be determined.

Sustainable Forest Management at Mngazana must recognize that the local communities utilize the mangroves for building construction and that the people have a right to access mangrove wood products. Given the socio-economic status of the local communities at

Mngazana, the demand for low-cost building materials will persist. Although there are alternatives to mangrove wood, it is highly valued and will probably continue to be used preferentially for building in the immediate future. Mangrove forests in other developing countries are under similar pressures to those of Mngazana (Semesi 1992; Dahdouh-Guebas *et al.* 2000) and the most immediate value of mangroves is placed on their wood products (Alongi 2002). Additionally, natural forests as opposed to plantation forests are often viewed as open access resources and as a result may be intensively harvested (Walters 2005b). Given these conditions, the extent to which these demands can be met needs to be analysed based upon a forest inventory.

SFM implies that there should be no decrease in wood products and that the capacity to regenerate be maintained. However, studies have demonstrated that 'small-scale, local woodcutting can be a significant form of ecological disturbance in mangroves' (Walters 2005a: 345), and it has been shown that forest structure was dramatically altered.

A desktop extrapolation, to determine the sustainability of current extraction rates, was made using published data from Adams *et al.* (2005). They reported that the density of trees greater than one metre high in the Mngazana Estuary was 230 *Bruguiera gymnorhiza* trees and 489 *Rhizophora mucronata* trees per hectare. As the Mngazana Estuary covers an area of 145 ha this suggests that there are $\pm 104\,255$ trees > 1 m height of *B. gymnorhiza* and *R. mucronata*. With an estimated annual demand of 18 400 stems, the annual off-take would be approximately 17.6%. The resource would last for five and a half years at the current demand, without any recruitment. This is only sustainable in the very short term. Such a desktop extrapolation can be used as a guideline within an adaptive management context. Further investigations concerning recruitment and growth rates are required to accurately assess sustainability. As Mngazana has already been subjected to past harvesting, the forest must be assessed to determine whether the present community structure is functioning in a desirable state or if current stands need to be improved. Harvesting needs to be planned so that the ecosystem functioning and biodiversity are maintained. Studies suggest that mangroves can be managed sustainably for their wood, the Matang Mangrove Forest in Malaysia has been managed since 1906 for commercial purposes and continues to be productive (Hogarth 1999).

SFM should also aim to broaden the range of benefits derived from the mangroves, particularly of non-consumptive uses. Activities such as mangrove honey production, could demonstrate that non-consumptive mangrove uses have the potential to generate incomes. External factors that may affect demand also need to be considered: at Mngazana these include the link between mangrove use and use of other indigenous timbers and alternatives to mangroves such as sand blocks. In the village of Cwebeni, a group was formed to produce and locally sell sand blocks for building construction. These blocks are durable, highly regarded as building materials and, if competitively priced, could reduce demand for mangrove stems. Other factors may indirectly affect demand for mangroves, for example clearing of the

coastal scarp forest for agriculture will reduce the supply of construction timber from these forests, builders may turn to the mangrove forests to meet their needs and thereby increase demand for mangrove stems. In the past, forest clearing for agriculture has reduced the supply of indigenous hardwood poles from coastal scarp forest in northern KwaZulu-Natal (Cunningham & Gwala 1986).

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OBITUARY

EILY EDITH AGNES GLEDHILL (NÉE ARCHIBALD) (1914–2007)

Eily Gledhill (Figure 1) was born on 7 September 1914 in Walmer, Port Elizabeth, as Eily Edith Agnes Archibald. Her father was a merchant in Port Elizabeth and her mother, Lilian Irving, a keen collector of succulent plants, particularly of the genus *Haworthia*.

Upon finishing her schooling at St Dominic's Priory, Walmer, Eily enrolled at Rhodes University where she completed her B.Sc.Cl.L. degree with Botany and Mathematics as majors. Later she obtained an M.Sc. degree in Botany with a thesis on jointed cactus; and went on to London University to do her Ph.D. thesis on plant populations. When Eily returned to South Africa she joined the Division of Chemistry of the Department of Agriculture. In 1941 she was appointed as lecturer at the Botany Department of Rhodes University where she continued the research in which she had been engaged at Chemical Services—relating soil survey results to plant distribution. In the 1950s, she was occupied with trace element research on citrus and pineapple cultivation in the Eastern Cape. It was at Rhodes University where Eily met and married Jack Gledhill, head of the Department of Physics and Electronics.

Eily Gledhill's botanical work included a survey of the Alexandria District as well as ecological surveys of the Fish River Catchment Area in 1946 and of the Greater Addo Elephant National Park in 1954. During this time she was engaged in assembling the ± 9 000 specimens that are today lodged in the Selmar Schonland Herbarium in the Albany Museum, in the National Herbarium in Pretoria and in the herbarium of the Royal Botanic Gardens at Kew. Many of these are signed cryptically 'E2A2' (Lubke & Brink 2004) which refers to the initials of her maiden name. With Dr M.A. Pocock and others she started the Rhodes University Herbarium to house the collections made by students. This has now been amalgamated with the Selmar Schonland Herbarium.

Eily described a number of new species and worked on a revision of the genus *Albuca*. She also published 'The genus *Dioscorea* in the Cape Province west of East London' in 1967. Many of her numerous publications were illustrated by herself with accurate black-and-white drawings. Furthermore, her book published in 1969 and with a second edition in 1981, *The Eastern Cape veld flowers*, in which she describes 554 species from 125 families, each illustrated by her fine line drawings, is still of great value to students of botany and the public at large (Figure 2). In the preface she writes: 'If this guide assists owners of land and visitors to know more about the plants of the eastern Cape, it will have achieved its object, for any one who becomes interested in this unique flora cannot fail to realise why it needs to be protected'. She coined the term *bonte-*

veld which has become recognized as a veld type and is widely used.

Eily Gledhill's interests were not only confined to plants. In 1939, she joined St John Ambulance and taught first aid and child care courses throughout her active life. Through this Eily was honoured in 1992 by Queen Elizabeth II, the sovereign head of the order, by her promotion to Dame of the Most Venerable Order of the Hospital of St John of Jerusalem.

Eily was a member of the British Ecological Society, the Royal Society of South Africa, the Botanical Society of South Africa, the Van Riebeeck Society and the South African Ornithological Society.

She also became more and more interested in local history and contributed to *The 1820 Settlers Illustrated*, edited by Guy Butler (1974) and to Rex and Barbara Reynolds's (1974) book, *Grahamstown: from cottage to villa*. She was instrumental in the restoration of many buildings including the Observatory Museum and in 1980 she researched and published with her husband a book, *In the steps of Piet Retief*, about the famous trekker's activities in Grahamstown as trader and farmer.



FIGURE 1.—Eily Edith Agnes Gledhill (1914–2007). By courtesy of St John Ambulance, Grahamstown. Copied by FotoFirst.



FIGURE 2.—Various members of Crassulaceae (taken from Gledhill 1969: t. 28).

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PUBLICATIONS BY E.E.A.GLEDHILL [NÉE ARCHIBALD]

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She realized the tourist potential of Grahamstown and published many pamphlets and booklets on frontier forts and founded the Grahamstown Guild of Tour Guides, leading many tours herself. Makana handicrafts, which created jobs for township women and Abalizi, a low-cost housing project, were also founded by her.

Eily Gledhill died on 30 May 2007 in Grahamstown where she had lived and worked for most of her life. She was a woman of great intellect and high principles but my (E. B.) most prized recollection of her was her delightful, quirky sense of humour which always lightened the working day at the herbarium whenever she visited her special friend, Grace Britten.

She is commemorated in *Haworthia eilyae* Poelln. (Gunn & Codd 1981).

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- E. BRINK* and G. GERMISHUIZEN**

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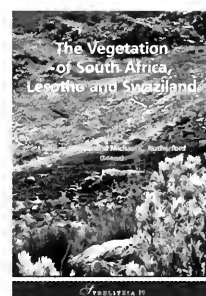
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STRELITZIA 18

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P. Goldblatt & J.C. Manning (May 2007)

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